Annual report of the Wisconsin Geological Survey for the year 1877. 1878

ANNUAL REPORT

OF THE

WISCONSIN

GEOLOGICAL SURVEY

FOR THE YEAR 1877.

BY T. C. CHAMBERLIN,
CHIEF GEOLOGIST.

MADISON, WIS.:
DAVID ATWOOD, PRINTER AND STEREOTYPER.
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To His Excellency, WM. E. SMITH,

Governor of Wisconsin:

SIR: I have the honor to submit herewith, in accordance with legal requirement, a brief report of the progress and results of the Wisconsin Geological Survey for the year 1877.

Most Respectfully,

Your obedient servant,

T. C. CHAMBERLIN,

Chief Geologist.

BELOIT, Dec. 31, 1877.

REPORT.

The evident purpose of the annual reports required by the law under whose authority the survey is being prosecuted, is to lay before the governor, the legislature, and the people, an outline of the progress made by the survey during each year, and a summary of its leading results, without attempting to present in detail the voluminous material accumulated, which, at the best, could only partially be given at so early a date as that designated for the rendition of the report. This view has been sanctioned by the action of successive legislatures, who have deemed it advisable to reserve the publication of details until they could receive careful study and be arranged in a systematic and convenient, as well as economical form, in the final report.

In accordance with this view, the present report will be made as brief as is consistent with the purposes it is designed to subserve, and the energies of the corps devoted to the elaboration of the more complete report.

In my last annual report, an outline of the work then remaining to be done was presented. The plan of work there foreshadowed has been carried into execution during the present year, as will be seen by the following outlines:

WORK ON THE COPPER RANGE IN BAYFIELD AND DOUGLAS COUNTIES.

The field work of the season was begun by Mr. E. T. Sweet, then of Madison, more recently of Colorado, in Bayfield and Douglas counties, on April 10, a date considerably earlier than that on which field work had been begun in previous years. The leading features of this survey are given in the following preliminary report by Mr. Sweet:

PROF. T. C. CHAMBERLIN, *State Geologist:*

DEAR SIR: I have the honor to submit, according to your request, the following brief summary of the principal facts connected with, and observed during, my late geological examination of a portion of Douglas and Bayfield counties.

Starting from Madison on the 6th of April, I arrived at Ashland on the 9th following. Here I engaged the services of a packer, and at once proceeded to Bayfield, where provisions and necessary supplies were obtained for a trip of two weeks to Superior City. A short distance from Bayfield, I entered the unbroken forest and established my first working camp at Siscawet lake, on Sec. 21, T. 50, R. 6 W. From here Siscawet river, and other neighboring small streams were followed to the shore of Lake Superior.

Proceeding westward, Bark, Cranberry, Flag and Iron rivers were followed, either up or down, from near the source to the mouth or near the mouth of each. Red sandstone is found within one or two miles of Lake Superior, in the banks of these streams. Ledges of the same rock also often cross the channels of the streams near the lake, causing falls of from two to ten feet in height. No exposure of any member of the Copper-bearing series was found along these streams nor in the highlands adjacent to them. At the Brulé river in Secs. 23 and 24, T. 48, R. 10 W., the Copper-bearing rocks are largely exposed. A half mile east of the river there are cliffs from 60 to 80 feet high. The rock is quite distinctly bedded, dipping to the southeast at an angle of 35°. Following the "range" east from this point, it drops down from 80 to 100 feet in the course of a mile, to the general level of the country, and is not again found prominent. That the Copper-bearing rocks form the nucleus of the peninsula of Bayfield, there can be little doubt; but the enormous thickness of the drift completely hides them from view. West of the Brulé river, there are numerous ridges or exposures of the Cupriferous rocks, all trending in a nearly N. E. and S. W. direction. As the "Copper Range" of Douglas county, consisting of the lines of exposures of the Copper series, extending in a more or less broken line from Black River Falls, on Sec. 21, T. 47, R. 14 W., to the Brulé river, on Sec. 23, T. 48, R. 10 W., was quite thoroughly examined by myself in the summer of 1873, while connected with the State Geological Survey, I did not deem it necessary to minutely

re-examine it. Some attention, however, was given to the old mining locations.

The Percival mine, on Sec. 22, T. 18, R. 10 W., was worked in the fall of 1873, by Gen. Sargent, with a small force of men.

A couple of shafts were sunk, not over twenty or thirty feet, however, and these with a little surface stripping constitute the extent of the work upon the vein. The "surface show" was exceedingly flattering, good stamp and barrel work being found near the surface. Several large nuggets of copper were encountered in stripping the vein, and in test-pitting. The work, however, was not continued a sufficient length of time to determine with precision even the character of the vein. The country rock is a dark, grayish, fine-grained melaphyre, often very amygdaloidal. The vein is from one to four feet thick, and is probably bedded, as it appears to dip with the formation. Epidote, with a small proportion of calcite, laumonite and native copper, make up the vein matter. I can see no reason why this mine should not prove to be a profitable one.

The Wisconsin mine, locally known as the Edwards mine, is located on Sec. 2, T. 47, R. 13 W. This mine is upon a true fissure. Two perpendicular shafts have been sunk upon the vein, one sixty and the other eighty feet, at an expense of about $14,000. At the bottom of the shafts the vein has a width of six feet, and carrys a small amount of native copper. A large number of fine specimens have been taken out. I am informed by Capt. Edwards that a half ton of copper was taken out in sinking one of the shafts the first fifteen feet. I consider this property as the most desirable mining location yet operated in Douglas county, and it is probably the only one upon a true fissure vein. Very little work has been done upon this mine since 1865.

The Fond du Lac mine is located upon Sec. 8, T. 47, R. 13 W. It has long been abandoned. Two shafts were sunk upon a bedded vein, dipping 30° to the S. E. A small amount of copper was found in the hanging wall. There was never a "good show" at this location, although about $12,000 were spent here.

The Copper Creek mine was worked by Gen. Sargent in 1864–5. It is located at the junction of the forks of Copper Creek on Sec. 15, T. 47, R. 14 W. Here the most extensive mining operations of Douglas county have been carried on. Four shafts from 30 to 40

feet in depth were sunk in 1846 by the North American Fur Co. Gen. Sargent sunk three shafts, and ran adits and tunnels from them, involving an expense of between $30,000 and $40,000. After thorough exploration, the location was abandoned as worthless. Copper to a considerable extent is scattered through the wall rock and vein matter. The veins, of which there were supposed to be several, were found to vary greatly in character at different depths. I am unable to indicate with certainty more than one. That is bedded and dips 55° to the S. E. It is an epidote vein, carrying calcite and quartz.

At Black River Falls, one and a half miles from Copper Creek, exploration to a limited extent has been carried on.

The river here descends in a nearly perpendicular leap of 160 feet. The vertical walls of the gorge for a half mile below the falls are nearly 175 feet high, affording a magnificent opportunity for examining the rock and taking a section, as the sandstones and conglomerate unconformably overlie the Copper-bearing rocks. A gorge existed at this place without doubt, previous to the laying down of the Lake Superior sandstone. It was filled with conglomerate and breccia from the Cupriferous rocks, and red sandstone, which have subsequently been but partially removed from the ancient gorge, in the formation of the present gorge. Detailed sections of the different beds of the Cupriferous series, so far as I am able to make them out, together with others taken on Middle river, Aminicon river, Copper creek and Black river, showing the relationship between the Lake Superior sandstones and Copper-bearing rocks will accompany my detailed report.

Upon arriving in Superior, I thought best to spend a day along the banks of the St. Louis river, and determine, if possible, the relationship between the slates and quartzites so largely exposed on that stream, and the Copper-bearing rocks located to the south and east of them. I find the strike of the slates to be always nearly east and west, and the dip always to the south at an angle varying from 36° on Sec. 11, T. 48, R. 16 W., the most southern exposure, and junction with the Lake Superior sandstones, to 58° on Sec. 5, T. 48, R. 16 W., just north of Thompson.

Although the junction of the slates and Cupriferous rocks was not observed, it is highly probable that the former are Huronian, and underly the Copper-bearing rocks, which are found a few miles

to the south. In the vicinity of Fond du Lac, and also southeast from Superior, evidences of ancient lake terraces are quite plain. I place them at about fifteen feet, eighteen feet, one hundred and twenty feet, and an indistinct terrace between three hundred and four hundred feet above the present level of the lake. From Superior City, I went to Copper creek and Black River Falls, and succeeded in tracing the "Range" to a branch of Black river, two and one-half miles from the falls of Black river. West from that point no exposures could be found. One and a half miles above Black River Falls there is a fall of thirty-one feet over greenstone. Above here for eight or ten miles along Black river there are no outcrops. I have been informed by Mr. Geo. Stuntz, who conducted the government surveys in nearly all of the townships in Douglas and Bayfield counties, that he saw only one exposure in townships 44 and 46, ranges 14 and 15 west. In 45, 15 W., he saw an outcrop of one of the members of the Copper-bearing series, which contained a few small veins, from which he pounded two or three small nuggets of native copper. As he was unable to locate it closer than the township, I thought it absurd to loose any of my limited time in searching for it.

From Copper creek, I followed the range nearly to the Wisconsin mine. Taking a S. E. course, I left the most southern exposure of the Cupriferous series that I found in following up the Aminicon river, in Sec. 15, T. 47, R. 13 W. After ascending the Aminicon river to Sec. 11, T. 46, R. 13 W., I made an excursion to the west six miles, to Aminicon lake, but found nothing worth mentioning except cedar, and tamarac swamps. Continuing in a southward direction, I struck the head waters of Moose river, and followed that stream nearly to the mouth. There is no outcrop of the Cupriferous series along the stream north of township 44. Although in that township they are frequently met with, but were not carefully examined by me on account of high water, and also from the fact that the southern boundery of my district is the south line of township 45. From Moose river, I went to Gordon's, at the mouth of the Eau Claire, for fresh supplies, and proceeded thence across the Barrens a short distance to the east of St. Croix lake, to near the head of Brulé river. After spending a day in canoeing upon the stream, the banks were followed to the mouth of the Nebagamin, and three days spent in searching for exposures along

the banks of that stream, and the Brulé, as well as in the adjacent country. I went to the exact spot of the sandstone exposures as mentioned by Mr. Ives in his manuscript report, but found only banks of sand and sandstone pebbles. Upon either side of the Brulé there are the most distinct terraces I have ever seen. A mile down the river from the mouth of the Nebagamin there are three; the first is 30 ft, the second 80 ft, and the third 190 ft above the present surface of the river. From the top of the highest terrace to the corresponding one on the opposite side of the stream, the distance is about one mile. As the stream is ascended a few miles, the terraces are not so much elevated above the stream, showing that the descent of the river is greater and the flow of water swifter now than in former times. Evidences of terraces were also observed upon the head waters of Flag and Iron rivers.

From the Brulé river, I took an easterly course to Spider lake, in Sec. 20, T. 47, R. 8 W., and from there a northeasterly course to Moose lake, in Sec. 5, T. 48, R. 6 W. Nearly the entire distance from the Brulé river to about ten miles northeast of Moose lake is across the Barrens. The soil is almost entirely composed of sand, and supports a very scanty growth of timber, locally known as Jack and Norway pine. Fires have run over the Barrens until there are now large tracts upon which there is no living vegetation. The surface of the country is very uneven, it being cut up by "potash kettles" from twenty feet to thirty feet deep, and often these are not more than two or three times as far across the top as they are deep. They appear to follow general lines of depression.

Small lakes are frequently met with from 100 to 150 ft. below the summit of the Barrens. Within a radius of three or four miles from Spider lake, they seem to be within 20 ft. or 30 ft. of the same level, and usually much nearer the same level. Other lakes in the vicinity of Moose lake are much larger, and others to the southeast lower. From Moose lake I proceeded to Ashland, passing across semi-barrens nearly to Fish creek, Sec. 9, T. 47, R. 5 W. I arrived at Ashland on the evening of the 9th of May.

It will be observed from the foregoing account, that I have passed over a considerable portion of the district assigned me for exploration. My district is bounded as follows: Lake Superior on the north; the town line between ranges 5 and 6, from Lake Superior

to the N. E. corner of T. 48, R. 6 W. on the east; then on the south east by a line running from the N. E. corner of T. 48, R. 6 W., to the S. W. corner of T. 40, R. 9 W.; on the south by the line between townships 44 and 45, and on the west by the state line. The area occupies upwards of 1,450 square miles. There are but three roads in the district, and they are impassable for wagons during the summer months. As I have had less than two months in the examination of the district, and as all supplies, specimens, etc., must necessarily be carried on men's backs, the duties have been unusually arduous. I think that enough has been done to enable me to map down with a considerable degree of accuracy, the formations, and the productive beds of the Copper series. No mines have been opened, and no productive veins have been discovered at a greater distance than 2,000 feet south of the line of the junction of the Copper-bearing rocks with the Lake Superior sandstone.

I have complete notes, with which, added to my manuscript report, I shall at an early day make out my final report. I have full notes on timber, soil, drift, and animal life, as well as upon suujects of ordinary geological importance.

E. T. SWEET.

MADISON, May 14, 1877.

WORK ON THE COPPER-BEARING SERIES OF THE UPPER ST. CROIX RIVER.

During the summer of 1876, the late lamented Moses Strong examined a belt extending from St. Croix Falls northeastward to the vicinity of Lake Superior. Between this belt and the territory examined by Mr. Sweet, there remained a triangular area yet to be investigated. Mr. Strong began the investigation of this region on April 20th, accompanied by Mr. David Caneday, who had assisted him during the previous year. Starting from St. Croix Falls, the party examined, in their progress northward, a belt of territory contiguous on the northwest, to that investigated last year. When the upper St. Croix river was reached, it was made the base alike of operations and of supplies, a boat having been transported to its head waters for that purpose. The main portion of the remaining area, not known to be covered by drift or Potsdam sandstone, was examined by lateral excursions from the river during its descent.

In the progress of these investigations, a large number of out-

crops of the several members of the Copper-bearing series, consisting of melaphyres, amygdaloids ("traps"), conglomerates, sandstones and shales, were located and examined, and data and specimens for further study taken. In a number of instances native copper was observed, and concerning some of these, Mr. Strong speaks in favorable terms. True fissure veins, as well as those amygdaloidal or other mineral-bearing strata known among miners as "veins," were found. Several fine deposits of shell marl, that in the futue unfoldings of this region will doubtless prove valuable, were examined by Mr. Strong, and other subjects of practical and scientific interest received attention, and important facts relating to the general geological structure of the region were gathered.

In previous years Messrs. Irving and Sweet, of the survey, had determined that the great synclinal trough, in which a portion of Lake Superior lies, is extended westward through Northern Wisconsin. To determine, as nearly as possible, the exact location of this is a question of both scientific and practical importance. The data accumulated is believed to be sufficient for the settlement of this question with approximate definiteness.

As this trough is but the downward folding of the strata constituting the Copper-bearing series, it was to be presumed that the same strata would occur on the two sides, though they were known to be much concealed by drift. To identify and corelate these was likewise a question of importance, which would require for its solution the combined observations of all parties engaged upon the Cupriferous series. Much valuable data bearing upon this subject was collected by Mr. Strong in the course of the explorations above indicated.

It has been impossible, in the pressure of other duties, for the writer to give to the notes left by Mr. Strong more than a general examination, and of necessity this outline very inadequately represents the work accomplished in the St. Croix region.

THE SURVEY IN BARRON AND CHIPPEWA COUNTIES.

In 1876, Mr. Strong made a reconnoissance of the northern part of Barron county, to determine the general position and relations of the interesting quartzites and pipestones of that region. The facts then gathered strengthened the belief that had been previously entertained, that these represent the Huronian, or Iron-bear-

ing series, and as the Penokee range was known to approach within less than 60 miles on the north, it became an important question to determine the extent of the formation, and its relations to the northern series. It had been planned that Mr. Strong should more carefully examine the formation in Barron county, and explore thence northward as far as means of access would advantageously permit, and afterwards, by means of the Chippewa river, and its tributaries, reach the more northern and inaccessible portions of the region to be surveyed. In accordance with this the work in Barron county was begun on the 31st of May. The known area occupied by quartzites and pipestone was considerably increased and much important information collected.

After completing this work, it remained to explore the east and west slope of the Upper Chippewa valley. It was planned that the eastern sides should be examined first, in the hope that the duties of the chief geologist might permit him to join Mr. Strong, at his earnest desire, in the examination of the area lying between the western extremity of the Penokee series and the quartzites of Barron county, about which so much interest had now gathered.

It should be remembered that the whole region is one of dense and continuous forest, untraversed, for the greater part, by roads of any kind, and that the only means of access is by boats on the streams, or by packing through the wilderness. In the latter case, all provisions, instruments, articles of outfit and shelter, as well as specimens, must be borne on the backs of men. As most of the exposures lie along the streams, the former method was, for obvious reasons, adopted so far as practicable.

It was proposed to traverse first, the tributary known as the Jump river and afterwards the Flambeau branches — but this plan was necessarily changed, as indicated by the following communication, *the last* received from our deeply lamented associate:

STEVENS POINT, August 15, 1877.

DEAR CHAMBERLIN: — I leave here tomorrow morning, and on account of very low water, I find it necessary to make the trip up the north fork of the Flambeau first, and thence down the south fork to Fifield.

You may send letters to me to Fifield station W. C. R. R., care of the station agent, via Stevens Point.

Very truly yours, MOSES STRONG.

The subsequent events are clothed with inexpressible sadness. The following account was prepared immediately after the melancholy event, by one whose facilities for obtaining the exact facts, exceed my own, and whose painful interest caused every incident to impress itself with unwonted force and vividness upon his feelings and memory.

"Mr. Strong left Stevens Point on Thursday, the 16th, accompanied by William P. Gundry of Mineral Point, and John Hawn of Stevens Point, a guide whom he had hired, who was familiarly known as "Sailor Jack," and who was an experienced woodsman, and an expert in canoe navigation. The party went by railroad to the crossing of the Flambeau river, where they arrived about six o'clock P. M. The next day — Friday — was spent in procuring boats and other preparations for ascending the river. Mr. Strong obtained a light skiff, made of riven white cedar, which he thought well adapted for the purposes for which he wished to use it. He also obtained a birch bark canoe, in which was to be transported the supplies and camp equipage for the party of three.

"They commenced the ascent of the Flambeau on Saturday morning and continued it for nine or ten miles, without any remarkable incident, until nearly three o'clock, P. M., when they came to some rapids, supposed to be in Sec. 28, T. 41, R. 1, E. The rapids were about 150 feet from the foot the head. The bed of the river was filled with numerous rocks, over and about which the water rushed rapidly. "Sailor Jack" took the lead in the bark canoe and its freight, followed by Mr. Strong and young Gundry in the cedar skiff. Jack had reached the head of the rapids, or nearly so, as the others were entering upon the ascent, Mr. Strong was standing in the bow of the skiff using a long light pole for propelling it, while Gundry was sitting in the stern using the oars for the same purpose. Near the foot of the rapids was a rock, past which they pushed the skiff far enough, so that the current struck its bow and turned it around the rock, in such a manner that the whole force of the current striking the boat broadsides, tipped it over. As it was about going over Mr. Strong jumped from it into the water, and stood upon a rock in the bed of the river, over which the water was about three and a half feet deep and came up to his waist. Immediately below the rock where he was standing and holding on to the skiff the water was twelve feet deep, into which

Mr. Gundry went, as the skiff upset. At that instant he hollowed to Mr. Strong: "I can't swim;" who replied: "Hold to the boat." Gundry held on at first, but in attempting to get a better hold, or in some way, lost his hold of the boat, and was carried into the water, into which he was sinking. Simultaneously, the skiff went down stream, and Mr. Strong left his position of comparative safety, and was immediately in the deep water, and sunk to the bottom of it, to rise no more.

"Why he left the place where he was standing and let the boat go, is a matter of conjecture. One theory is that he slipped and could stand there no longer, but this is not as probable as is the theory of the men who were engaged in searching for his body, which is that as soon as he saw that his friend Gundry had lost his hold of the boat, and was sinking, he threw himself into the deep water, in the vain (as it proved) effort to save his companion from drowning. He was a good swimmer, very self confident, and self reliant, and would not have been likely to apprehend any disaster to himself in the effort to save his friend, and if he had, the apprehension would not have deterred him.'

"The reason why he did not reach Gundry is very satisfactorily explained by Gundry himself, who says that while he was under the water, he distinctly saw Mr. Strong with his legs drawn up, as in a sitting position, and his arms bent in front of his breast, in which position he sank, and his body was in this position when found. It therefore would seem quite certain that in his effort to save Gundry, Mr. Strong was seized with cramps, which deprived him of the power of swimming, and resulted in his own drowning, and the certainty is increased by the fact that his body was found on the bottom of the river, not more than thirty or forty feet from where he had been standing.

"That Mr. Gundry escaped drowning is almost miraculous. He drifted down the river until his feet struck a sand-bar, which enabled him barely to get his head above the surface of the water. Here he stood in water up to his neck, until he was rescued by Jack Hawn. As soon as Jack heard the cries, he left his canoe at the head of the rapids and ran to the foot of them, where he saw Gundry's head above the water, and the skiff floating down stream. He immediately rushed into the water and secured the skiff, and with it rescued Gundry from his peril.

"The time of the accident was five minutes to three, as indicated by the watches of both the young men, which were stopped at that time by being submerged. The body of Mr. Strong was found at six o'clock on Sunday evening, in $8\frac{1}{2}$ feet of water, having been twenty-seven hours in the water. It might probably have been found sooner, but for the erroneous supposition of those engaged in the search, that it had drifted further than proved to be the fact."

At the time the crushing news was received, his father, the Hon. Moses M. Strong, was at Stevens Point, and, through a generosity and courtesy that commands our warmest admiration, a special train was placed at his disposal by General Manager E. B. Phillips, of the Wisconsin Central R. R., whereby he was enabled to reach, at an early hour, the scene of the disaster.

The remains were conveyed to Mineral Point, where they were laid to rest, amid the profound sorrow, not alone of kindred and friends, nor of the community by which he was so highly esteemed, but of the entire commonwelth in whose service he had fallen.

Of the history and character of our lamented associate, I deem it appropriate to speak more at length in another portion of this report.*

The loss to the survey, though immeasurably less than the unspeakable affliction to the smitten family, is very great. Mr. Strong's careful notes, even up to the very hour of his death, were all recovered in a legible condition; yet, though they were taken with that painstaking care that so prominently characterized his work, they can never receive at the hands of another that fullness and completeness of elaboration which they would have received from their author.

Section 6, of the organic law of the survey provides that the salaries of the corps "*shall be for services actually performed and for time actually spent in the work.*" In obedience to this injunction, the payment of the salary of Mr. Strong ceased with the installment for the month in which he was drowned.

That the remainder of the salary thus withheld should be made good to the widow and children, thus suddenly bereft of their dependance for support, needs neither argument nor precedent, though amply supported by both, and I deem the simple statement of the facts a sufficient recommendation to the legislature to do all

*See Appendix.

that it legitimately can to mitigate a loss that, even in its financial aspects, is largely beyond repair.

RE-ORGANIZATION.

The loss of so important a co-laborer caused a serious embarrassment to the plan of operations above outlined. It was at once evident that before another party could be organized and placed in the field, so much time would necessarily elapse that it would be impossible to complete the work contemplated. Two parties were therefore, with some difficulty, organized; one in charge of Mr. F. H. King, to whom was entrusted the examination of the valleys of the two Flambeau rivers, and the other under Mr. F. H. Brotherton, who was charged with the exploration of the territory on the west side of the Chippewa river.

WORK ON THE FLAMBEAU RIVER.

The plan pursued by Mr. King in the examination of the Flambeau region was the same as that adopted by Mr. Strong. The north fork of the Flambeau was ascended to the mouth Turtle river, when that stream was examined to the point where it leaves the heavy drift region, after which the ascent of the Flambeau was resumed. The lake region on its headwaters was examined sufficiently to ascertain the character of the drift accumulations, which exclusively occupy it and effectually conceal the underlying rock formations. Passing across to the headwaters of the south fork, or Dore Flambeau, the examination of the formations along it was accomplished in its descent.

Before the examination of the main river, below the junction of the two forks, was completed the cold weather had so far advanced as to close the stream with ice and compel the party to abandon their boat and complete the journey on foot, which was accomplished on the 14th of November.

In the progress of this work, fifty-nine outcrops were located and examined, and specimens taken for more critical examination in the laboratory. Of these, thirty-six occur in the north fork of the Flambeau, twenty-one on the south fork, and two on the Turtle river. The rocks represented in these consist of granites, gneiss, mica shists, syenites and hornblende-bearing rocks. They undoubtedly all belong to the great Laurentian series. The strike is quite

uniformly northeastward, varying from N. 35° E. to N. 80° E. To this there are one or two apparent exceptions. From the varying dip, it appears that the strata are much folded, and three or more anticlinal axes seem to be indicated. The whole territory drained by the two Flambeaus has been subjected to powerful glacial action, and an immense sheet of drift covers the whole region, except where subsequent erosion of the streams has cut through it and exposed the rocks. These drift accumulations, and the modifications to which they have been subjected, were made subjects of study, the results of which will be given in the more complete report. The timber and the soils also received attention, and the distribution of each was mapped, so far as the nature of the work would permit.

WORK ON THE WEST SIDE OF THE CHIPPEWA RIVER.

The explorations under Mr. Brotherton revealed what had, in a measure, been anticipated; that the region between the Chippewa and Nemakagon rivers, from Barron county to Lake Nemakagon, is almost universally covered with deep drift, which effectually conceals the underlying formations and greatly embarrasses the determination of their character, and renders the results of examination correspondingly less positive and satisfactory.

The drift, and its clothing of soil and vegetation, received due attention. The most important result relating to the rock formations, was the finding, in Sec. 16, T. 38, R. 8, W., a ledge of red, granular, and, in part, conglomeritic, quartzite, in every respect resembling those of the pipestone region, southward, and undoubtedly belonging to the same series.

This lies about thirty-five miles west of south of the southwestern extremity of the Penokee series, as previously traced. The strike of this quartzite is given by Mr. Brotherton as S. 50° W., and the dip as 20° S. E., or, in other words, its strike is approximately parallel to the Penokee series, and its dip in the opposite direction.

SURVEY OF THE PENOKEE RANGE.

Besides the examinations in earlier years, a careful detailed magnetic and geological survey of the portion in the vicinity of Penokee Gap, and westward to Nemakagon lake was made last year.

During the present season this work has been extended over the eastern portion of the range to the Michigan boundary. It was planned that Prof. Irving should extend the careful survey made by him at Penokee Gap eastward to the Potato river, and that Mr. C. E. Wright should examine that portion lying contiguous to Michigan, with whose formations he was especially familiar. The first part of this plan was carried out in full by Prof. Irving, as will be seen by consulting the following report, which gives an outline of this important work.

MADISON, December 24, 1877.

Prof. T. C. CHAMBERLIN, *State Geologist:*

SIR: I present you herewith, according to the law, my annual report as Assistant State Geologist.

My last annual report bears date December 28, 1876. From that time until the middle of July, 1877, I continued to be occupied with the work of preparing and seeing through the press my description of the "Geology of Central Wisconsin," which forms part of the recently issued Vol. II of the final reports of the survey.

The legislature of the previous winter having ordered the continuance of the survey for an additional year, it was thought right to extend the detailed work begun in the summer of 1876, so as to cover the entire length, in Wisconsin, of the Huronian belt or "Iron Range" of Ashland and the adjoining counties. In accordance with this plan, that portion of the Iron Range which lies between the passages of the main Bad river and its Opinike or Potato branch, was assigned to me. Nearly the whole region watered by the systems of the Montreal and Bad rivers, had already been investigated by the parties under my charge, in 1873 and 1876, and the district now to be examined was already well known ground, much of it having been traversed twice. This previous knowledge was an indispensable to the detailed work which it was now proposed to do.

In accordance with our understanding, I proceeded to Ashland on the first of August, having secured the services of Mr. Paul B. Wood, surveyor and engineer to the Peshtigo Lumber Co., as woodsman and compassman. Mr. Wood's long experience in surveying in the woods and his skill in the use of instruments, were of the greatest assistance. Having hired an Indian packer and laid in

a good stock of provisions, we went first, by rail, to Penokee Gap. In the summer of 1876, the detailed topographical and magnetic mapping of the vicinity of the Gap had been carried northward as far as a line crossing through the middle of the north half of Sec. 11, T. 44, R. 3 W. Where this line meets the west line of Sec. 11, is a narrow ledge of slaty rock, some hundreds of feet in length from east to west, which rises abruptly on all sides to a height of 175 feet above the low ground at its foot, and from the summit of which can be obtained one of the very few extended views afforded by this densely wooded country.

Beginning with this rock, a measured geological, topographical and magnetic section was carried northward along the section line 5½ miles to the railroad, in T. 45, R. 3, W. The section thus made covers the remainder — about half a mile in horizontal width — of the slaty, Lower Huronian, or Iron-bearing series, the uppermost layers of which are to be seen as a fine-grained, gray, hornblende slate, about five hundred paces north of the corner of sections 2, 3, 10, 11, T. 44, R. 3, W. Further north, is crossed a belt of rocks showing large ledges of a coarse, pink, feldspathic granite, entirely surrounded by others of a dark colored fine to very coarse-grained rock, much of which is a gabbro, or diabase, and which preponderates in amount over the granite. Further north still, the section crosses the melaphyrs of the great Copper or Keweenian series, and ends on the railroad track near the crossing of Silver Creek, Sec. 10, T. 45, R. 3, W. From here we returned southward, along the railroad track, to Penokee Gap, passing on the way the large ledges of granite and diabase which show along Bad river, in sections 19, 30, and 31, of T. 45, R. 2, W., 6 of T. 44, R. 3, W., and 1 of T. 44, R. 3, W. These ledges had all been examined in 1873, but were now carefully relocated and re-examined under the light of greater experience.

The result of this work is, then, the obtaining of two new and carefully measured lines across the widest part of the interesting, and, as yet, somewhat doubtfully related, series which intervenes between the true Huronian and Keweenian rocks. The belt of country occupied by this series narrows as it is followed eastward, until, at the Montreal River, it has almost disappeared, the Keweenian and Huronian here approaching closely to one another. The same thing is true of the western extension of this belt, for at

the west line of T. 44, R. 5 W., the slaty Huronian rocks lie not more than a mile south of ledges of amygdaloidal greenstones and melaphyrs of the Keweenian series. About a dozen lines have now been run across this belt at different places along its whole length, and each of the streams crossing it has been followed, besides which numerous scattering outcrops have also been located, so that I shall be prepared, after a careful study of all the results, and microscopic examination of the specimens, to give a full description of the series, as also to come to a reliable conclusion with regard to its geological relations.

Reaching Penokee Gap again, we began with the eastern side of the detailed work of the previous year, on the east line of Sec. 14, T. 44, R. 3 W., and spent about four weeks in mapping the Iron-bearing series as far as the passage of the Potato in the western part of T. 45, R. 2 E. The plan adopted for this work was to cross the iron belt, which, although quite sinuous in its course, preserves still a general east and west direction, curving more and more towards the north as it is followed eastward — from north to south at distances of about half a mile, using the section lines as much as possible. On each of the crossing lines stations were established at every hundred steps, and at every station the aneroid barometer, the variation of the magnetic needle, and the time, were carefully observed, a simultaneous series of barometrical observations being carried on at Ashland. The lines were begun at points far enough to the south, on the Laurentian rocks, to be out of the influence of the iron or magnetic belt of the Huronian, and were extended northward far enough, not only to be out of the influence of this belt in that direction, but also to determine the presence or absence of any other similar belt or belts. Some of the lines, moreover, were extended further than the rest, so as to pass on to the next series of rocks, allusion to which has been made above. Other subordinate lines of observation were frequently run across the sections in an east and west direction, and all the lines were controlled by constant reference to section corners and quarter posts. All outcrops were of course examined and located, and specimens were taken for subsequent study, particular attention being given to the magnetic belt traversing the centre of the Penokee Range. The largest outcrops are found where the several branches of Bad river break through the range from the southward. At each one of these gorges

the work was carried into greater detail, in order that the true succession of the various layers might be made out.

Many interesting facts were developed during this detailed work, one or two of which may be mentioned here. The exact junction of the Huronian and Laurentian series was found at the gorge of Potato river, where a cliff-side over 100 feet in height, and over half a mile in length, is traveased near the middle by the highly inclined contact-line between the "silicious slate," one of the lower members of the Huronian, and a greenish chloritic gneiss of the Laurentian. The silicious slate inclines at a high angle to the north, whilst the gneiss layers dip to the south and strike in a direction oblique to that of the slate layers. It is worthy of note that the two lowermost layers of the Huronian, as seen at Penokee Gap and for many miles to the eastward, the "white quartz" and "silicious dolomitic marble," are here entirely absent; but this fact is quite in accord with the relations everywhere to be observed between these two widely distinct rock series. Another fact of importance is the steady lessening of the disturbing influence exerted on the magnetic needle by the iron belt of the Huronian, as it is followed eastward. In its more western extension, the variations observed on and near this belt are commonly as much as 90° to 180°, the disturbing influence extending, moreover, for a long distance to the north and south of the line of greatest disturbance. By the time the Potato river is reached, the variations never approach 90°, and are to be observed along a very narrow belt only. Still further east the attraction lessens yet more rapidly, and on the Montreal river you have yourself observed that it is essentially lost. This lessening in magnetic attraction does not necessarily indicate a corresponding decrease in the amount of iron present in the rocks of the iron-belt, but rather that the magnetic oxide is giving way more completely to the non-magnetic, or sesquioxide, which is always present, in greater or less quantity, even where the magnetic attractions are greatest. The outcrops observed bear out this conclusion; for a considerable quantity of very highly manganiferous red hematite is to be seen at points all along from the passage of Tyler's Fork, eastward.

Yet another point of interest brought out by this year's work is the apparent demonstration of the non-existence of other magnetic belts in the more northern or upper portions of the Huronian se-

ries. Hematite, or specular ores, may exist here, but the gaps in the series of layers have now been so largely filled up, that it appears probable that any discoveries of ore which may be made in the future will be on the already known magnetic belt.

Completing the work assigned us early in September, we returned to Ashland to find your request that I should extend the detailed examinations over the space still remaining between the Potato and Montreal rivers. When I went into the woods it was understood that this piece of work would be done by Mr. C. E. Wright, and I had made such arrangements with regard to my classes at the University that it was now necessary that I should return to Madison.* I would have been glad to go back to the iron range at the beginning of the season of 1878, had you not thought it right to have all work finished up before the date of the legal conclusion of the survey.

Since the close of field work in September, I have been occupied in the study of notes and specimens, and in the preparation of maps, etc., for my report on the Lake Superior regions, which will appear in Vol. III of the final reports. The following is a very brief outline of the plan of this report, with some explanations of present interest:

I. The General Rock Structure of the Country bordering Lake Superior. This will be a brief discussion of the grand features of the several rock systems of this region, with their relations to each other and to the extensions of the same groups in other parts of the Lake Superior basin. These northern regions have been separated, since the earliest geological times, by the Laurentian mass of the northern part of the state, from the regions further to the south, and, as a result, have had an entirely independent rock growth, and one contrasting greatly with that of all other parts of the state.

II. The Geology of Ashland County, and the Adjoining Portions of Lincoln and Bayfield Counties. This district includes all the country lying between the south line of township 44 and the shores of Lake Superior, and stretching from the Mon-

*It should be understood that on account of his engagements at the University, Prof. Irving declines a portion of the salary to which he would otherwise be entitled. T. C. C.

treal river on the east to the west line of range 5 west, on the west. It includes also the group of the Apostle Islands with the adjacent coast of Bayfield county. The report begins with a full description of the topographical features of the region — including its river systems, altitudes, soils, vegetation, etc. — after which the several rock formations which cross the country in parallel bands, the oldest being the furthest removed from the lake shore, are taken up in the following order:

(1.) *The Laurentian Rocks.* These constitute the main mass of the Archæan of the northern half of the state, and are the southernmost of those of the region under consideration. They include a number of kinds of gneiss and granite, with some schists; but, so far as yet known, no metallic ores. A careful study of these rocks is, nevertheless, of economical importance, since they limit on the south the iron-bearing formation. A considerable number of exposures have been examined, the largest of which are to be seen along the Marangouin, Bad, Tyler's and Potato rivers, near to where these streams pass onto the Huronian.

(2) *The Huronian Rocks.* In this series, which includes the iron belt of the Penokee Range, a great number of distinct layers have been recognized, up to a total thickness of several thousand feet. Each of these layers has its peculiar lithological characters, and is found occupying a constant position throughout the whole length of the Huronian belt. In view of the great importance to future mineral explorers of an accurate recognition of these various layers, no pains have been spared to fix their characters as fully as possible. A typical suite of specimens has been sent to Mr. A. A. Julien, of New York, for microscopic examination and description. Mr. Julien's long experience in this kind of work on the equivalent formations in Michigan and other states, will enable him to furnish exhaustive descriptions. In addition to this, I shall myself examine microscopically a large number of specimens from all portions of the series. The specimens to be distributed by the Geological Survey can, moreover, always be referred to by those interested.

The report on these rocks will be accompanied by four atlas plates, upon which the exact positions of the various layers will be mapped on a scale of nearly four inches to the mile. These plates will show also the deflections of the horizontal magnetic needle at

the various stations occupied, as above explained; and will give a large number of vertical magnetic geological cross sections, with contours based upon the aneroid observations. The several gorges through the iron range, where the exposures are especially large and important, are mapped on a still larger scale. The practical importance of these various maps can hardly be exaggerated, because, by their aid, the mineral explorer can tell, within a few steps each way, where lies the belt upon which only it is of any use to explore. The enlarged map of Penokee Gap will develop the existence of a fault or very sharp bend in the strata at that place, which has led several geologists to believe in the presence of two distinct magnetic belts, when in fact there is but one.

The Penokee Iron Range has now been examined in greater detail than any other area of corresponding extent in the state. The larger part of it has been two or three times traversed by my parties, besides which Mr. C. E. Wright has made an independent detailed examination of that portion which lies west of Penokee Gap, and the chief geologist himself has examined the easternmost end. Every ore out-crop has been visited, sampled, and the samples analyzed. As far as purely geological work, without the aid of digging, is concerned, it may be safely said that the region is practically exhausted. The *outcropping* ores of the whole belt are, in general, lean and siliceous, though in places nearly rich enough to be of value, always remarkably free from hurtful impurities, and always highly manganiferous. It must, however, be remembered, that an outcropping *rich* ore is a great rarity, since, on account of the comparative softness, it is almost invariably crumbled and overlaid by loose material. Large portions of the magnetic belt are without outcrop; the investigation of these, the geologist now hands over to the mineral explorer, who will find in the maps which we furnish, a reliable guide as to where to explore.

(3.) *The Upper Huronian Rocks.* This is the series of diabases and other allied rocks, including also granites, etc., which has been mentioned above. No ores are known to occur in these rocks, but they are of great interest as regards their relations to the other adjoining formations. It is not at all improbable that more or less of this series should be thrown in with the Keweenian or Copper-bearing rocks.

(4) *The Copper-bearing or Keweenian series.* This great rock

series, which forms the synclinal trough in which a large part of Lake Superior lies; constitutes the mountainous backbone of Keweenaw point, from where it can be traced westward, along the south shore of the lake, to the Wisconsin boundary at the Montreal river. Further west, the series recedes from the lake shore, but, spreading out over an area many miles in width, extends entirely across the northern part of Wisconsin. In the district under consideration, the copper rocks are generally much covered by drift or lucustrine clays, except at the passages of the several northward flowing streams — the Montreal river, the Little Potato river, the main Potato river, Tyler's Fork, Bad river, Trout brook (the outlet of English lake), Silver creek, Brunschweiler's river (outlet of Bladder lake), the Marangouin river, and White river. On the larger ones of these streams the exposures are on a grand scale. These streams have been followed, and the succession of layers determined. Maps will be furnished of several of the gorges, showing also the locations and geological relations of the views and beds on which copper mining has been attempted. Mention was made in my last annual report of the supposed identification of the Iron river (Michigan) silver horizon, at the point where the copper rocks cross the Montreal. Samples of the rock selected here in 1876 have since been assayed, and the presence of silver, in minute quantity, shown. A large series of specimens from the Copper series is now under examination by Professor Pumpelly, who has given much attention to the same formation as developed in the important copper-mining districts of Portage lake and Keweenaw Point, Michigan; and it is hoped that we may be able to furnish nearly as good a guide to explorers on the Copper series, as that offered to those interested in the Iron-bearing formation.

(5) *The Lower Silurian Sandstones.* These underlie the entire coast region of Ashland and Bayfield counties, besides forming the basement rock of the Apostle Islands. Outcrops of the formation are numerous, and a great many have been examined. At two points a very fine brownstone is quarried, and the same rock can, without doubt, be obtained at other places.

(6) *The Quaternary Deposits.* These are developed on a grand scale in all of the Lake Superior region, and consist of two well marked divisions, of which the older is the true Glacial Drift, the newer being the Champlain lacustrine clays. The Glacial

Drift is difficult to investigate on account of the densely wooded nature of the country, but it is present in great force, immense boulders studding the surface everywhere, and masks the rocks with a heavy coating, especially on the northern faces of the ridges. The lacustrine clays form the shores of lake superior, extending also many miles inland, and having a great thickness. They are finely exposed to view in both the lake cliffs and on the sides of the many streams which make gorges through them. A great many of these exposures have been closely examined, and some interesting facts developed, among which not the least important is the existence of a great deal of clay quite as well adapted to the making of brick as any of the well known clays of eastern Wisconsin, which, like those of Lake Superior, are commonly very rich in carbonate of lime.

In addition to the Atlas Plates of the Huronian Series, and other maps mentioned above, the report will be accompanied by a general geological map of the whole region, another of cross-sections illustrating its structure, a special map of the Copper Series, and a number of cuts to be placed in the text.

ROLAND D. IRVING,
Assistant State Geologist.

Mr. Wright, who now sustains the relation of Commissioner of Mining Statistics to the state of Michigan, found himself unable to give to the Wisconsin survey the time necessary to make the examination of the eastern portion of the range, and this work was undertaken by the Chief Geologist, in person. In this he was efficiently assisted by Mr. A. D. Conover, of Madison.

The plan of the work was essentially the same as that which had been carried into effect on the adjacent portion of the range, as above described, and need not be repeated here. Aside from the accurate mapping of the iron belt and the associated rocks, some of the more important results — and they are deemed quite important — may be briefly indicated:

Eastward from the Potato river, the magnetic attractions rapidly diminish, and become closely associated with a belt of black slate lying north of the silicious schists that form the crest of the ridge at many points west of the Potato river. East of the Fourth Principal Meridian this black slate attains greater topographical prominence, and at many points forms the crest of the ridge.

The maximum magnetic attraction is usually manifested on the southern margin of its outcropping portion. It is itself magnetic, owing to the dissemination through its mass of grains of magnetite.

When the Gogogashugun river, the main tributary of the Montreal, is reached in T. 46, R. 2 E., the magnetic disturbance has almost entirely disappeared. This disappearance might be supposed to be due to the absence of iron ore, but the evidence presented on the Gogogashugun river clearly indicates that, on the contrary, the loss of magnetism is due to the replacement of the magnetite by the non-magnetic hematite and limonite ores.

At the falls of the Gogogashugun a most interesting section may be made out. The falls themselves are due to the barrier imposed by the silicious schists that here form the lowest exposed member of the Huronian series. By going back from the falls a short distance, guided by the indications of the loose blocks of rock on the surface, the party were fortunate enough to uncover, at their first attempt, the exact junction between the Laurentian and Huronian series. The Laurentian member consists of a peculiar gneissoid rock, altogether like that which occupies a similar relation at Penokee Gap. Its strike is N. 67° W., and its dip 49° N. E. The Huronian rock lies in absolute contact with this, not even being separated by a fissure. Indeed, at one point, the silicious material that formed the Huronian rock had, at the time of its deposition, so insinuated itself into the irregularities of the surface of the gneiss that the two formations are interlocked and *a hand specimen* was obtained, one portion of which is Laurentian gneiss and the other Huronian schist, the two being, of course, unconformable. It is doubtful whether a similar specimen has ever previously been secured.

The base of the Huronian series as here exposed is formed by grey and purple silicious schists, interleaved with which are occasional purplish layers of a clay-like texture. Some of these approach a pipestone and raise the question — which of course they are not competent to answer—whether they are not the approximate equivalents of the pipestones of Barron county, which sustain a somewhat similar relation.

The general strike of these schists is N. 55° E., and their average dip about 60° N. W. By comparison with the Laurentian strata, it will be seen that the two formations strike across each

other at a large angle and dip in opposite directions. The surface width of this stratum is 317 feet.

The schists are overlaid by more massive beds of white and red quartzites, which occupy a belt at the surface about 200 feet in width. These graduate into a series of alternating layers of quartzite and iron ore, which are but partially exposed and soon become entirely concealed by drift. The iron ore consists of red hematite and limonite.

Where exposed, these have been largely eroded, owing to their softness, giving rise to intervals between the projecting layers of quartzite. The average resisting power of these alternating layers is less than that of the adjacent quartzites and silicious schists, to which fact is doubtless due their deeper erosion and limited exposure. Wherever they outcrop, the amount of quartzite is much greater than that of the associated iron ore, otherwise they would undoubtedly have been more deeply eroded and concealed. There is also present with the iron ores a considerable relative proportion of manganese.

The special significance of these facts is this. To the westward where the attractions are strong, magnetite and specular hematite are associated in a precisely similar way with quartz rock, and occupy a corresponding horizon. It becomes quite evident then, that the loss of magnetism in this eastern portion is not due to an absence of iron ore, but to a replacement of the magnetic and specular ores by the softer red hematite and limonite. It is highly probable that all these ores were originally of the same character, and that their present variation is due to different degrees of oxidation and hydration. Oxidation of the magnetic ores would produce the hematites, and hydration of these, the limonite. We may be justified, then, in suggesting that the eastern portion of the range has furnished, at some time in the history of the formations composing it, freer access of air and water, and is therefore presumably of more open texture. This harmonizes with the fact that the range in this portion has suffered more erosion as shown by its flattening out eastward. It is also to be observed that the rock-horizon of these hematites and limonites east of the meridian does not project on the crest of the range, and sometimes occupies a more or less evident depression between the silicious schists on the south and the magnetic slates on the north, where both outcrop or approach

the surface. It is along the line of this depression and between the schists and slate, that the greatest probabilities of the existence of workable ore are presented, and the facts, in my judgment, justify a prudent and intelligent expenditure of means in testing the region by the interested parties.

CREVICE SURVEY OF THE LEAD REGION.

Section 2 of the law authorizing the survey, provides for "a careful topographical survey of the Lead region, for the purpose of ascertaining, as far as possible, the amount of denudation and the exact amount of mining ground at each locality," but it makes no specific mention of the lead-bearing crevices.

This omission, taken in connection with the amount of work specifically required to be done, which was very large in proportion to the time and funds granted, as experience has shown, led the Chief Geologist in charge of the survey at its beginning, to the opinion that he was not at liberty then to order a detailed survey of the mineral-bearing crevices of that region, and instructions were given to Mr. Strong, who examined the region in 1873 and 1874, in accordance with this view, so that, while a geological and topographical survey was made, the metalliferous crevices were not mapped. When the survey was placed in charge of the writer in 1876, the large amount of unfinished work in other regions, and the limited amount of time and funds then at his disposal, rendered it unadvisable to undertake this work, although he had from the beginning regarded it as authorized by the general provisions of the law, and as very importaut to a satisfactory elucidation of the lead deposits. But the last legislature having very generously extended the time for the completion of the survey, this work was undertaken. After consultation with Mr. Strong, who had made the geological and topographical survey of the region, and who would have been a most competent party to have executed the proposed work, it was deemed advisable that he should continue his unfinished work on the Copper-bearing series of the north, in accordance with his preference, and that the survey of the crevices should be placed in the hands of Mr. James Wilson, Jr., who had had many years' experience in this and allied work in Grant county.

In 1860, the geological survey then in progress, under Prof. J. D. Whitney, located the greater proportion of the crevices then worked,

but from the limited facilities afforded, the work was not, in this respect, exhaustive and, in some instances, as was almost inevitable under the circumstances, was based on inaccurate information. The data of this survey have been verified and adopted so far as found trustworthy, and 866 additional mineral bearing crevices or patches have been surveyed.

In addition to the location and direction of the crevices, the nature of the deposit, its depth, its position in the crevice and relation to the water level, the location of bars and various other facts bearing upon the origin and character of the metalliferous deposits have received attention, and statistics supplementary to those previously obtained were collected. The following table, prepared by Mr. Wilson, shows the geographical distribution of the work, besides giving in a convenient form some valuable information. The first column of figures gives the number of crevices surveyed during the year at the several localities indicated. The second column gives the number adopted from the survey of 1860, and the third the total number of important crevices at the places named. The remaining columns show what proportion of these are approximately north and south, east and west, quartering, in patches, and irregular, respectively.

TABLE OF CREVICES.

Names of the Localities.	No. of crevices located.	No. from survey of 1860.	Total Number.	No. of E. & W. crevices.	No. of N. & S. crevices	No. of quartering crevices.	Patches.	Irregular crev-ices.
Muscalunge	.....	.....	122	110	1	11	1	....
Nip and Tuck	1	28	28	22	6	.....	1	...
Beetown	21	16	37	35	1	1	....	....
Hackett	.....	4	4	3	1	....	....	....
Little Grant	1	.....	1	1	.....	.....	.....	....
Pigeon	46	.....	46	21	7	5	11	2
Hurricane Corners	3	.....	3	3	.....	.....	....	....
Boice Prairie	8	....	8	4	4	.. .	....	..
Potosi and Dutch Hollow	42	7	49	43	6	.....	.....	....
Buena Vista and British Hollow	29	2	31	13	1	16	1	...
Rockville, Pin Hook and Red Dog	.....	22	22	19	1	....	2	....
Menomonee, or Jamestown	.....	.....	40	.....	...	40	.....	....
Lower Menomonnee, or Kilbourn	2	17	19	19	....	.....	.....	....
Fairplay	27	45	72	72	.....	.....	.....	....
Shawneetown	.....	6	6	6	.....	.....	.....	....
Hazel Green	.....	.....	621	314	214	93	....	....
Buzzard's Roost	19	5	24	5	4	16		...
Benton	30	138	268	114	29	25	....	....
New Diggings	38	165	203	129	55	19	....	....
Shullsburg	30	84	114	45	24	35	....	10
Wiota	20	7	27	22	5	.....	....	....
Sugar River (Exter)	5	.....	5	5	.....	.....	.....	....
Moundville	29	.....	29	28	... .	1	.....	....
Between Moundville and Porter's Grove	5	.....	5	.....	.....	.....	5	....
Porter's Grove	40	.....	40	4	24	10	2	...
Dodgeville	83	.....	83	12	35	6	1	29
Van Metre Survey	65	.....	65	47	3	.....	15	....
Mineral Point	79	.....	79	57	14	4	4	....
Lost Grove	12	.....	12	5	4	....	.....	...
Diamond Grove	19	.....	19	6	6	6	1	....
Linden	61	.....	61	32	20	2	...	7
Highland	25	.....	25	13	4	5	1	2
Centreville	3	.....	3	2	.....	.....	....	1
Wingville	15	.....	15	15	.....	.....	.....	....
Crow Branch	10	.....	10	2	3	5	.....	....
Washburn	2	... .	2	... ..	2	.....	.....	....
Mifflin	23	.....	23	3	6	14	.....	....
Platteville	53	39	92	82	.....	6	.....	....
Whig	15	.....	15	13	.....	2	.....	....
Brush Hill	5	.....	5	3	2	.....	.....	....
Total number of crevices	866	.....	2,232	1,327	482	322	45	51

Two of the above at Highland, and one in the town of Little Grant, are in the Lower Magnesian limestone: the remainder are in the Trenton and Galena limestones.

Six of the above named localities, viz.: Hackett, Hurricane Corners, Rockville, Pin Hook, Red Dog and Shawneetown have not yet been visited, but from information received, the ranges are thought to be located correctly so far as they are given in the old survey. There are, however, many more paying crevices than those given in the above list.

The sickness of Mr. Wilson, and the unusually unfavorable fall weather and early closing of the season, curtailed the work, and a number of localities yet remain to be visited.

It was deemed advisable to make a more elaborate and critical survey of some of the more impartant and significant districts, for the purpose of showing more exactly and specifically the method of the mineral deposit, the character of the openings, and their relations to the topography, to the formations, and to the drainage systems. Such a survey of the Muscalunge Diggings, in Grant county, has been made. By completing the careful surveys he has made during the progress of mining in past years for the parties owning the mines, Mr. Wilson now has a complete undergrouud survey of the crevices belonging to what is locally known as the "65 foot opening," except a few of the first opened, which were filled with waste material. The exact direction of the summit or watershed of each ridge and of the ravines, the slope of the surface, the flow of the water in the streams, and of the underground currents of water in the diggings, and their discharge into openings below, have been carefully observed.

MINING IN THE LOWER MAGNESIAN LIMESTONE.

Mining operations having been recently prosecuted in the Lower Magnesian limestone, near Highland, by Mr. Ohlerking, an examination of the locality was made by the writer in September, and subsequently the drifts were carefully surveyed by Mr. Wilson, who located them upon the surface of the ground, and made a topographical survey of the vicinity.

The mine is located on the slope of a ridge, the summit of which is formed by the Trenton and Galena limestones, the steep slope by the St. Peters sandstone, and the base by the Lower Magnesian

limestone. The shaft penetrates 45 feet of the sandstone, and about an equal depth of the Lower Magnesian limestone.

From near the base of this shaft a drift has been extended along an opening in a somewhat irregular course, as follows: in a direction N. 1° E., a distance of 8 ft. 8 in.; thence N. 45½° E., 17 ft.; thence N. 82½° E., 31 ft. 8 in.; thence N. 69½° 14 ft. 8 in., where it divides, one portion continuing on in a course N. 80° E., for 16 ft. 6 in., where the working terminated at the time of our visit. The other portion extends N. 28° E. for 15 ft. 4 in., where it terminates.

A branch drift commences at 30 feet from the shaft and extends N. 5° E., for 15 feet 4 inches, when it turns to N. 13½° W., and continues 14 feet 8 inches, when it changes again to N. 16° E., for a distance of 16 feet, the limit to which it had been worked. An older drift has a direction through about 90 feet of its course of N. 16° E., connecting at its southern end with one extending 30 feet in a direction N. 63½° W. The entire extent of the drifts was about 280 feet.

The opening was largely filled with clay and decomposing rock, and contained considerable quantities of the reddish, slightly cohesive substance, known among miners in some localities as "joint clay." The wall rock is not well defined, the clay and decomposing material apparently graduating into the unmodified strata. At the extremity of one of the drifts there was an irregular space between the unmined clay and the arching roof of the opening, and I was informed that this was a common fact. That which is regarded as the cap rock, consists of a layer of silicious dolomite about one foot in thickness, over which lies a stratum of greenish blue clay shale of somewhat irregular thickness, averaging perhaps six inches. The openings probably had their origin in fissures around which the rock has decomposed, giving rise to the present clay filling. The lead ore was mostly taken from within the clay, being neither at the bottom nor top. I extracted a piece, however, that was firmly imbedded between two undisturbed layers of rock. The ore seen was chiefly in large cubes, considerably worn or corroded on the surface, and often coated with the carbonate of lead. The amount raised was stated by Mr. Ohlerking to be about 5,000 pounds. Independent testimony to the amount of about 3,000 pounds was obtained. I am informed by Mr. Ohlerking that mining has been resumed.

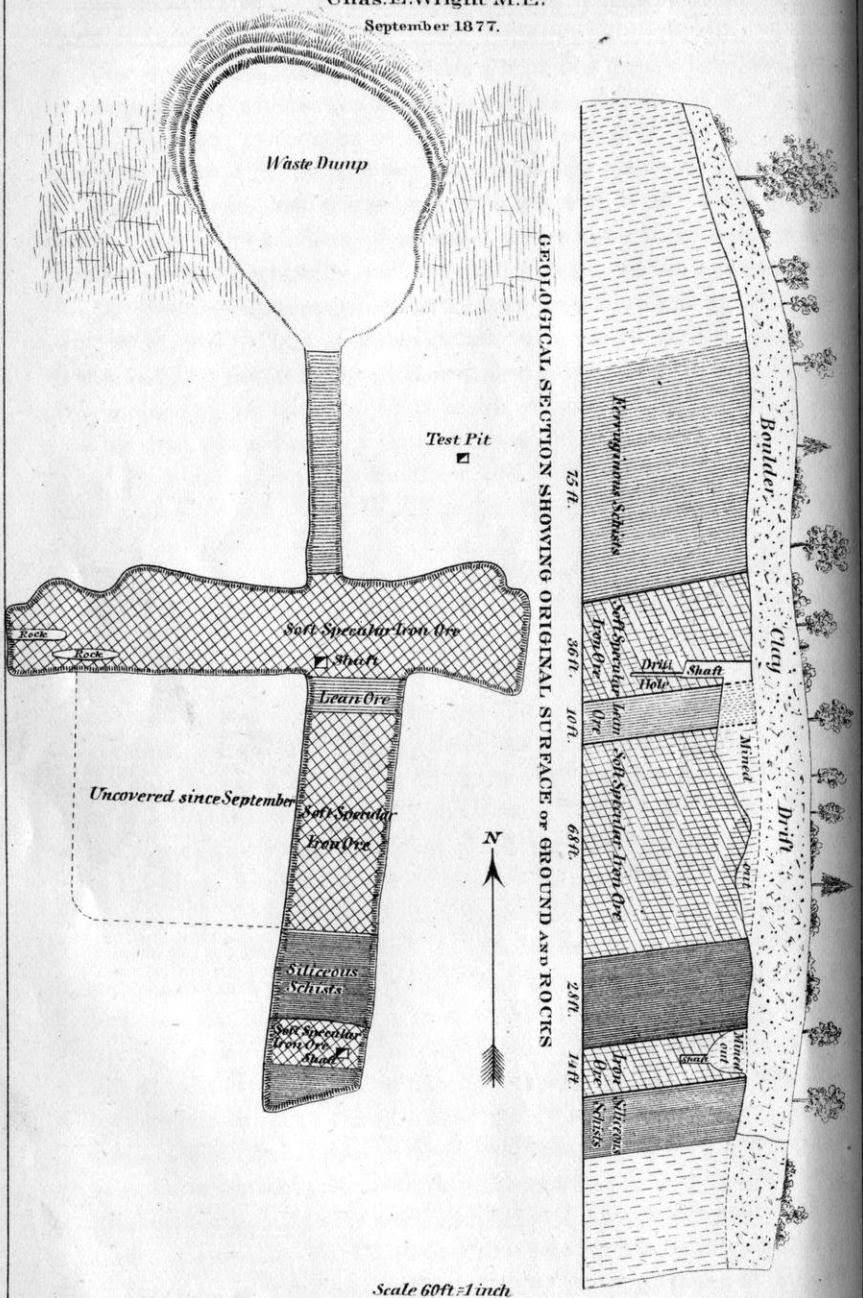
These leading facts are given at this time in advance of the full

SKETCH OF
COMMONWEALTH IRON MINE

by

Chas. E. Wright M.E.

September 1877.



THE MILWAUKEE LITHO. & ENGR. CO.

report and discussion of the subject, because of the numerous inquiries that have been made respecting this enterprise, and the general interest that is felt in the subject.

SURVEY OF THE PINE RIVER IRON DISTRICT IN OCONTO COUNTY.

The eminent desirability of a continuation of the investigation of this promising region was indicated in my last report. Special arrangements were made with Major T. B. Brooks and Mr. Chas. E. Wright to continue the work that had been in progress under their charge in previous years Both of these experts have been in the field in person. A brief outline of the important developments in their district will be found in the accompanying report of Mr. Wright.

PROF. T. C. CHAMBERLIN, *State Geologist:*

SIR: In compliance with your request, I herewith submit to you the following preliminary report of the work performed this season in Oconto county. The outlook in the Menominee river district, from an economic standpoint, is much brighter than it ever was before, and it has been thoroughly demonstrated that Wisconsin has one iron mine — the Commonwealth — that has more ore in sight than did any of the Lake Superior iron mines at its stage of development. The formation dips high to the south. The ore is of a soft steely specular variety, which, in a shaft, gradually becomes harder as they sink in depth. An average sample collected by myself at every six inches across the first 36-foot vein — see diagram of the mine — afforded, after being pulverized and thoroughly mixed, a little more than sixty-three per cent. of metallic iron.

This is certainly very good, especially when we consider that this was across the original upper surface of the ledge, and was taken without any regard to quality.

By consulting the sketch, it will be seen that there were uncovered last September three beds of ore, which are respectively thirty-six, sixty-eight, and fourteen feet in width, giving an aggregate thickness of over one hundred feet, measured at right angles to the bedding planes.

The beds of ore are alternated by strata of lean ores, ferruginous and silicious schists. The mine is very favorably located on a high broad ridge, and the lands along this range are covered with

fine hardwood timber, and the soil, a rich sandy loam, is well adapted to farming purposes.

The Chicago and Northwestern Railway Company, with their usual promptness to assist in the development of any new country contiguous to their lines, are now making a reconnoisance of a railroad route to this mining section. Nothing appears wanting to transform this recent isolated, unprofitable portion of the state, into a busy iron center. The existence of large and paying deposits of iron ore can no longer be questioned by the most skeptical, and one fact is worthy of note here, that, notwithstanding the apparently exaggerated reports that were circulated during the past summer, not a single person, as far as I can learn, has visited this locality without being agreeably disappointed.

At the Eagle mine, nearly two miles north of the Commonwealth range, the formation dips to the north. Considerable exploring has been done on this property, and the results should encourage the owners to do more. A small amount of work immediately to the north of their present openings would add greatly to their knowledge of this deposit. It is in my own judgment, an equivalent of the Commonwealth series, though as to its extent or value, hardly sufficient work has been advantageously performed to warrant the expression of a decided opinion. North of this range a little less than two miles passes another iron belt; and south of the Commonwealth, between it and the Pine river, are two other iron ranges. All these iron belts, I consider, were originally of the same geological horizon. I will not attempt to give any hypothesis of the structure of this region, preferring to wait until I have carefully worked up my field notes taken farther to the west. The plan of work adopted was to run parallel north and south lines, eighty rods apart, from the granite south of Pine river to nine miles north, on the eastern portion of our work, but gradually lessening the length as we progressed westward, owing to the northwesterly trend of the formations. In this manner we completed our work to the east line of range 15 east. On all these lines were observed the magnetic attractions, both with the dipping needle and solar-dial compass. We also noted the rocks and kinds of timber, the quality of the soil, and the topographical features of the country passed over. Just here it may be stated that the incompleteness and "general crookedness" of the United States govern-

ment linear surveys caused us much trouble at first, until after learning, "by leg-weary experience," that the usual method of these, frequently, justly censured surveyors, was to "go around" a block of four sections at a time, blazing a tree now and then, so that, in case they should become bewildered, they might, by a careful retracing of their steps, aided, perhaps, by the compass, find their way out again. In this manner, they would manage to see two sides of each section; but the result is, that some of the sections are nearly a mile and one-half on one side, and less than a mile on the opposite side. This is no exaggeration. Another fact which may greatly aid explorers is, that where there is a large amount of swamp lands laid down on the United States plats, it usually signifies that the lines were never run, and instead of swamp lands, one is just as likely to meet with fine hardwood as swamp.

Soon after entering range 18, the formations generally assume an average course of N. 65° W. The iron-belts already mentioned cross ranges 17 and 16, and I hope when our field notes are carefully worked out, to be able to locate very nearly where they cross the different sections. It must be remembered that these ores are chiefly specular, and have only slight attraction for the needle. We came upon several belts of magnetic attraction, some of which could be readily followed, one in particular, that crosses the N. W. $\frac{1}{4}$ of Sec. 36, the N. E. $\frac{1}{4}$ of Sec. 35, the S. $\frac{1}{2}$ of Sec. 26, and diagonally through Sec. 27, T. 40, R. 16. Our limited time, however, did not permit of tracing these belts, but only to note where they intersected our north and south lines of observation. What would add greatly to the rapid development of this section of the country, would be the careful location of these iron-belts. If this were done it would, in a measure, prevent the often worse than useless waste of time and capital which is only too common to all new mining districts. It appears to me, viewing the situation from an unbiased standpoint, and knowing, too, something of the great value of our Lake Superior mining interests, and how largely they add to the revenues of Michigan, and, too, how many millions of dollars, one may safely assert, have been thrown away in foolish adventure, when a little systematic exploration would have proved the value or worthlessness of property, that the interests of the state of Wisconsin would be best promoted by doing some more

detail work within the area already gone over, and by extending the field farther to the northwest.

Very respectfully yours,

CHAS. E. WRIGHT,

Iron Expert.

WORK IN ST. CROIX, DUNN AND ADJACENT COUNTIES.

Mr. L. C. Wooster was assigned the investigation of the above region last year, and during the present season some additional field work and the elaboration of the data collected have been in progress. A summary of the results obtained is given in the accompanying report.

Prof. T. C. CHAMBERLIN, *Chief Geologist:*

SIR: — In accordance with your instructions, the exploration of the area assigned me has been in progress during portions of the summers of 1876 and 1877. This area includes St. Croix and Dunn counties, and portions of Chippewa, Eau Claire, Pepin, Buffalo and Pierce counties — over two thousand square miles.

The following is a tabular view of the formations examined:

I. Paleozoic
- 1. Upper Silurian (wanting).
- 2. Lower Silurian.
  - *a.* Trenton limestone.
  - *b.* St. Peters sandstone.
  - *c.* Lower Magnesian limestone.
  - *d.* Potsdam sandstone.

II. Archæan.

The coarse granite at Chippewa Falls is the only exposure of Archæan rocks visited, and, so far as known, is the only outcrop in the above district.

The Potsdam sandstone was found to be very fully represented, over seven hundred feet being included in the sections in preparation. In the midst of all the diversity in lithological characters, the following *persistent* horizons were discovered:

The numbers indicate the distances below the Lower Magnesian limestone.

a. Upper Calcareous Band. — This varies greatly in thickness, and is the probable northwestern equivalent of the Mendota limestone near Madison; 75 to 85 feet.

b. Lower Calcareous Band. — The limestone characters and the thickness are more uniformly persistent than in *a;* 145 to 195 ft.

c. Hudson Trilobite Beds. — Quite rich in trilobites and brachiopods, including one new species of the former, with several undetermined ones; 150 to 200 ft.

d. Glauconite Layers. — These comprise those layers which are very rich in glauconite. Crinoid stems were found in these at Hudson; 160 to 210 ft.

In *b*, *c* and *d*, the lesser distance from the Lower Magnesian is true for western St. Croix county, while the greater is nearer true for points east.

e. Eau Claire Trilobite Beds. — These hold at least seven species of trilobites — of which three are new — and a few brachiopods. These beds mark the lower limit of calcareous matter in the formation; 450 ft.

f. Eau Claire Grit. — These layers mark the upper limit of the coarse sandstones, almost conglomerates; 680 ft.

Work upon the Potsdam was commenced at Hudson, on Lake St. Croix, and for a time much difficulty was experienced in running parallels between the layers at Hudson and the layers exposed east and west of that point. But as data accumulated, it became evident that Hudson Bluff occupied the summit of an anticlinal axis trending S. S. W. The following are the elevations of the base of the Lower Magnesian in eastern St. Croix county, above Lake Michigan. Though the line of junction is not shown at all these points, the figures approximate *very closely* to the true elevation:

Stillwater, Minn.	190 feet.
Hudson	330 "
Three and a half miles to the east	140 "
Marine	290 "
New Richmond	231 "
On Lake St. Croix (Sec. 24, T. 28, R. 20 W.), five miles S. of Hudson.	280 "

At Stillwater and Marine the upper layers of the Potsdam are present, but east of Hudson, the formation is not exposed for a distance of thirty miles, when the upper layers are shown with increased thickness. Along an east and west line in the vicinity of Hudson and Stillwater, the change of elevation in the upper layers of the Potsdam is nearly three times as great per mile, as the change of elevation of the same in eastern St. Croix and Dunn counties. This would indicate a disturbance in the position of the layers near Hudson, and, although this, with the above considerations, may not demonstrate the existence of an anticlinal with an accom-

panying synclinal to the east, yet they render the presence of the same highly probable.

The line of junction between the Potsdam and Lower Magnesian is usually well marked, the limestone characters extending below the line, rather than the sandstone above; but the transition is frequently abrupt. A brecciated layer is generally present in the sandstone, while the lower portion of the limestone is always brecciated.

In general, the lower portion of the Lower Magnesian is heavy bedded to massive, and frequently cavernous, while the upper portion is medium to thin bedded, and holds most of the chert. The layers of this portion are nearly horizontal above, but much curved or arched below, apparently being arranged in a series of mound-like elevations, five and six feet in hight. The only fossils discovered are gasterpods, which were found both in the chert and in the upper layers. Near the line of junction with the St. Peter's sandstone the layers are frequently oolitic, and locally conglomeritic.

The transition to the sandstone is sometimes gradual and at others abrupt. When abrupt, from two to three feet of angular chert is said to be struck in wells, between the sandstone and limestone. In the vicinity of New Richmond, there appear to be bodies of sandstone in the upper portion of the Lower Magnesian, which may, possibly, represent the horizon of the Jordan sandstone of Minnesota. These are penetrated by but three wells in the neighborhood (Sec. 23, T. 30, R. 18 W.). The following data were obtained from Mr. Straight, owner of well No. 1 (No. 2 is owned by Mr. Church, and No. 3, by Mr. Robinson:)

	(1)	(2)	(3)
To rock	25 ft.;	(about) 15 ft.;	10 ft.
In limestone,	28 ft.;	(about) 15 ft.;	3 ft. ("thin slaty limestone").
Sandstone...	7 ft.;	(about) 15 ft.;	12 ft.

These data were obtained from Mr. Straight while at New Richmond, and on visiting his well the following morning, we were so unfortunate as to find him absent from home. The material thrown from the well showed white and yellow sandstone and oölitic limestone; the latter evidently from layers near the upper line of junction.

At about the same horizon, a thin layer of white sand is shown

at New Richmond, and a similar one, only thicker, southwest of River Falls, Pierce county. At all points in the district, this horizon is marked by curving layers over and around mound-like elevations, indicating a period of disturbance or unequal deposition before the uniform horizontal layers above were laid down, and during which a sandstone may have been deposited in Minnesota and in favorable localities in Wisconsin. In central and eastern St. Croix county, on the Willow river, the horizontal beds of limestone have been partially removed, leaving the two to three feet of angular chert on the surface. The wells in this part of the county quite uniformly penetrate the limestone fifteen to twenty feet for water, striking it at the horizon of the New Richmond sandstone.

The much greater extent of the mounds in eastern Wisconsin, and the deposition of the St. Peters sandstone upon and around them, may indicate a continuance of the peculiar influences there during the time that the horizontal layers were deposited at the west, or that the deposition of sandstone at the east commenced before, and continued during the deposition of those layers.

Further than a nearly uniform thickness of one hundred and twenty-five feet, little of interest was discovered in the St. Peters sandstone. Frequently the upper portion was found sufficiently indurated to stand forth in vertical walls and columns, but usually the stone is quite friable.

In southern St. Croix and northern Pierce counties, the St. Peters sandstone is protected from denuding agencies by a few feet of Trenton limestone.

This limestone is quite fossiliferous and, where well exposed, carries at its upper portion two to four feet of blue shale, likewise fossiliferous.

The succeeding periods are not represented till we reach those of the Quaternary age. During this age the transition from one period to the other was so gradual that it has been found nearly impossible to draw a dividing line between the deposits of each; or even, in many instances, to distinguish between them, as the later must have received much of its material from the earlier. Glacial drift is believed to be everywhere present, but is not always shown at the surface.

Erratics of large size from the north were found on the tops of the highest bluffs and in the banks of the larger streams; in the one

case being more elevated than the later deposits, and in the other having been brought to view from beneath by erosion. The northwestern portion of St. Croix county is traversed by a series of bluffs and kettle holes, with a few serpentine ridges, but I should hesitate to ascribe these to glacial action, were it not for the fact that morainal deposits have been found continuous with this series in the adjoining district. No striation or planing of rock surface was discovered, but glacial valleys are evident, especially to the north.

The lacustrine and fluvial deposits form numerous level tracts or prairies throughout the district, and, along the streams, have been cut into terraces, especially on the St. Croix and Chippewa rivers.

The erosion of these deposits during the Recent period gave two principal terraces to the large rivers, besides several of limited extent; and along these streams, where the drift was light, the erosion has continued till the rock has been left in vertical walls on each side, one hundred feet in hight.

It may be a question, however, whether these gorges were not marked out, at least, during pre-glacial times. Observations upon the surface soils were continued through the two seasons, and it was fouud, that, though there is a less number of kinds in the district than in eastern Wisconsin, there is a greater diversity in the arrangement, the areas being detached and irregular.

The cause of this is evident, when we remember the close proximity of the Archæan formations, and the comparative thickness of sandstone and limestone exposed.

The tops of the limestone ridges and tablelands, being still covered to a great extent with glacial drift, are quite fertile, while the river valleys below in the Potsdam sandstone are nearly barren; isolated patches of clay here and there being the only redeeming feature. The large percentage of calcareous and argillaceous material, however, in many layers of the Potsdam, renders the valleys excavated by creeks in this formation, together with the other areas which receive the material brought down by showers from the same, the most productive tracts in the district. Observations upon the flora of the district were made by my assistant, Mr. E. M. Hill, and have been embodied by him in a report which has already been presented to you.

Here, as elsewhere, the character of the vegetation furnishes one of the best indications of the nature of the soil.

Other topics of interest were investigated, but as I have already extended this outline beyond its proper length, their consideration will be deferred till the final report

Respectfully yours,

L. C. WOOSTER.

GREELEY, *Colorado*, *December* 28, 1877.

WORK IN NORTH CENTRAL WISCONSIN.

WAUSAU, WIS., *January* 7, 1878.

Prof. T. C. CHAMBERLIN,

Dear Sir: In compliance with your request, I send you herewith a brief outline of the geological work done by me in this region. It is necessarily short, but will, I trust, meet the requirements of your report, as it indicates the nature and character of the work done, and describes the general features of the region.

Having previously collected supplies and suitable equipment, field work was commenced on the 25th of September, and the remainder of the month and first part of October was spent in an examination of the Eau Claire river and adjacent region. This stream was ascended to T. 33, R. 11 E., where the southern boundary of that moraine drift region, which seems to extend across the northern part of the district under consideration, was ascertained.

To the south of this unstratified drift region, a belt of country was observed, extending south in the Eau Claire valley to the southern half of town 30. This region is covered with a stratified drift, apparently to a considerable depth, and is distinguished by the flat or gently undulating character of the surface and absence of rocky outcrops or angular surface rock. The soil is very fertile and, except in swamps and creek bottoms, is everywere covered by a luxuriant growth of hardwood, or hardwood and hemlock. South of the above belt, commencing in the southern half of town 30, extending through town 29, we meet with a tract of country in which drift material is light or absent. The topographical features are entirely different from the foregoing region, the general surface being hilly, and the valleys deeply cut. Rocky exposures and outcrops are frequent, and belong to the Laurentian series. Through Secs. 12 and 18, T. 29, R. 9 E., the river runs almost uninterruptedly over beds of Laurentian gneisses and schists. Extensive out-

crops of coarse red granite are also met with in this region. The soil is good, but often stony, and is covered by a growth of hardwood and hemlock.

South of this tract, through town 28, the surface changes, becomes level, and consists of a stratified drift, the soil being for the most part poor and sandy, the vegetation being Norway pine (Pinus resinosus).

After finishing the Eau Claire valley, an examination of the Rib river and adjacent territory was made. This stream was ascended to town 32, where the unusually low water prevented further progress in this direction. From the best sources of information, I think it probable that the southern limit of the morainic drift is about the middle of town 33, or near the sources of the Rib river.

South of this, we seem to have the same belt of stratified drift as on the Eau Claire; this extends south to about the northern boundary of Marathon county. South of this, we have a tract extending through towns 31, 30 and 29, in which the drift covering is light, the general surface, hilly and the valleys, deep cut. Rocky ledges and outcrops are common and seem to belong entirely to the Laurentian series. The soil is rich and fertile, and where not too stony, forms excellent farming land.

Examination in the Wisconsin river valley and its smaller tributaries has been carried up to the southern limit of town 32, and on Prairie river to town 33. The underlying rock, so far as met with, seems to belong entirely to the Laurentian series. The same topographical belts met with on the Eau Claire river can be traced here. First, the morainic drift region, the southern limit of which is probably between towns 33 and 34. Second, the assorted drift, extending south to the northern boundary of Marathon county, with probably here and there an isolated patch which rises above the general surface of the drift. Third, south of the last in town 30, a district of considerable elevation in which the drift material is light and sometimes absent, the surface characterized by high hills (100 to 300 feet) and deep valleys.

Examination on Pine river shows the underlying rocks to be Laurentian schists, covered with heavy stratified drift.

Examination of Trap river shows the underlying rock to be a coarse granite, generally of a red color, probably continuous with

that met with on the Eau Claire river, and which probably extends east and west for a considerable distance.

Examination of Marshall hill shows an underlying rock different from anything observed elsewhere in this region. It seems to be nearly related to the porphyritic rock met with in the hills immediately east of Wausau, and may possibly belong to the Huronian series. It seems to be an isolated tract, as rocks of undoubted Laurentian character surround it on all sides; fuller details in regard to this and other parts of the region will be found in the notes already forwarded. Notes on the vegetation have also been forwarded.

Before concluding, I wish to tender acknowledgments for the assistance of D. L. Plumer, Esq., of Wausau, a gentleman who has formerly been extensively employed as a surveyor in this part of the state, and who, in addition to the topographical knowledge thus acquired, has a natural taste for geological observation.

Yours respectfully,

A. C. CLARK.

SUMMARY OF FIELD WORK.

To foregoing constitutes an outline of the organization and prosecution of the field work during the year. It will be seen that eleven districts, of varying extent, have received investigation at the hands of an equal number of parties. All these parties, with a single exception, have previously been connected with the survey, and all have had experience in the special work which they have undertaken. Field work was begun nearly one month earlier, and continued nearly two months later, than in previous years, though no one party has been engaged continuously for so long a period as before, owing to the large number of districts to be examined, and the peculiar nature and relations of these, and the circumstances of the survey, that rendered it advisable to employ a larger number of parties than usual, the reasons for which have been already in a measure indicated.

The work has been guided by the experience of past years, and by such light as a familiarity with the field could give, and we trust that the results, when they shall be wrought out, will show that it has been prosecuted with vigor and success.

CHEMICAL WORK.

The analytical work of the survey has continued, as during last year, in the hands of Prof. W. W. Daniells, of the State University, and Mr. Gustavus Bode, of Milwaukee. The analyses which they have made will appear in the reports of the several parties for whom the work has been done, and will be there duly accredited.

MICROSCOPIC LITHOLOGY.

Within the past few years, there has been developed what may, perhaps, justly be called a new department of physical science. It consists of the determination of rocks and minerals by means of their optical properties, particularly as manifested by transmitted polarized light. Slices of rocks are made by suitable appliances so thin as to be, in a measure, transparent, and these, when examined under a microscope provided with the necessary optical adjustments, reveal many important characteristics not otherwise ascertainable. This method of investigation is peculiarly applicable to rocks whose constituents are so minute, or so blended, as to render determination by the usual method more or less unsatisfactory. To this class belong many of the rocks of our Copper-bearing series. Prof. Raphael Pumpelly, of New York, who adds to his accomplishments in this specialty, a thorough familiarity with the Cupriferous series in its most productive portion, and who has written an able treatise on the formation in the report of the Michigan Geological Survey, has very generously consented to examine, microscopically, specimens from the various portions of the Wisconsin series, and compare them with those from Michigan. He magnanimously offers to do this valuable work without compensation for his personal services.

Prof. Irving has indicated in his report, elsewhere, the arrangements which he has made for similar microscopical work upon the Huronian and Laurentian rocks of his collection. In the volume of the final report that has been issued during the year, Mr. Chas. E. Wright describes from microscopical examination some specimens of Archæan rocks from central Wisconsin. He has also studied a large number from the Iron-bearing formations that he has surveyed, and delineations of these will enrich his report on those regions.

It may be appropriate to add that Dr. Weichman, of Germany,

has prepared for Major Brooks a series of elaborate and critical descriptions of the Huronian rocks of the Pine River Iron District, which will form a valuable feature of the report on that region. It is proper to state that this, and a portion of the preceding microscopical work was done in previous years, but as it has not been mentioned specifically in the published reports, it is appropriate to speak of the whole here collectively.

DRAFTING.

The work of this department, which assumes increasing importance in the preparation of the final report, has continued, as heretofore, mainly in the hands of Prof. W. J. L. Nicodemus and Mr. A. D. Conover, of the State University. They have, during the year, completed the drawing of the maps for the atlas accompanying volume II of the final report, and a portion of those for the remaining volumes, and several others are in various degrees of advancement.

PALEONTOLOGICAL WORK.

Prof. R. P. Whitfield has continued his work upon the invertebrate fossils, which constitute the great mass of those which characterize the formations of Wisconsin. He has elaborated many of the preliminary descriptions of new species, preparatory to their final publication, and has prepared drawings of new and characteristic species for engraving. The lithographers have already commenced work upon these. Preliminary descriptions of some of the more important and interesting new species are herewith published.

Dr. J. S. Newberry, the able chief geologist of Ohio, has very kindly investigated the fish remains collected from our Hamilton cement formation, the leading results of which are given in the volume of the final report already published.

ZOOLOGICAL WORK.

The character and *personnel* of this work was indicated in my last annual report, to which reference is here made.

During the year, Dr. Hoy has continued the preparation of his report on the fishes, reptiles and insects of the state, and has added by observation to his already large information respecting these important divisions of our native fauna.

It is believed that his report will embrace all of the reptiles that are denizens of the state, and nearly all of the fishes. It is probable that some small or rare species of fishes in our lakes and northern waters may have eluded observation, but the report may be expected to embrace all the important species. From Dr. Hoy's, numerous and long continued observations and from his inter est as fish commisssioner in the practical bearings of the subject, the chapter on the fishes will doubtless be a very valuable one. The almost numberless species of insects prevent, at present, even an approximate list of those found in the state, but a valuable contribution on this subject may be expected.

Mr. King has followed the plan heretofore pursued for determining, as definitely as possible, the food of our native birds.

The contents of the digestive organs of 630 specimens, representing 102 species, have been examined during the year. Ten of these species had not previously been studied by him. The food obtained from about 600 of the specimens taken has been preserved in alcohol for further study, with a view of approaching more nearly to a specific determination of the insects that often form a large ingredient of it.

Taken together with the observations in previous years, Mr. King now has notes, made from direct inspection, on 1,642 birds, representing 190 species. This includes essentially all that have any important relation to our agricultural and horticultural interests.

Mr. W. F. Bundy, of Sauk City, who has made a special study of our crustaceans, and has described several new species found in our state, has kindly consented to furnish a list for our reports.

BOTANICAL WORK.

The observations on the timber and other forms of native vegetation, made in connection with the geological examination of the several districts, constitute, perhaps, the most important element of the botanical work of the survey. But, in addition to this, it has been deemed very desirable to place on permanent record as complete a list as possible of the plants indigenous to our state before they disappear through cultivation and pasturage, and the antagonism of imported species. Dr. Lapham had prepared and published, before the inauguration of this survey, a very full list of our phenog-

amous plants and partial lists of some of the lower orders. It is my desire to retain this as a monument of his patience and industry. Since his lists were published, however, some changes in the classification and nomenclature of the species have been adopted by leading botanists, necessitating the revisal of the list. A number of additional species — considerable when reckoned by themselves, but very few compared with the large number listed by Dr. Lapham — had been observed by others, and it was important to catalogue these also. Prof. G. D. Swezey, of Beloit College, has very generously undertaken the task of perfecting the list of phenogams. A preliminary catalogue was prepared by him and published at my personal expense, and distributed to the botanists of the state in the hope that the observations of the season would render it, as nearly as possible, complete. These have not yet been recalled, and the results of the effort are not yet known.

Prof. G. R. Kleeberger, of the Whitewater Normal School, has consented to revise the list of mosses, and Prof. Bundy has in preparation a partial list of the extensive order of fungi.

These gentlemen have generously undertaken this work without expectation of pecuniary reward, and their services are deserving of grateful recognition.

PUBLICATION.

No inconsiderable element of the year's labor has been the completion and publication of volume II of the final report.

The engraving was commenced last year, early in October, and occupied the greater part of a year. The printing and binding consumed about five months and a half. The most careful attention has been given to the execution of every portion of the work, and the amount of time and labor which this has involved can only be appreciated by those who are familiar by experience with similar publications.

The provisions made by the commissioners of public printing for the execution of the work proved highly satisfactory, and much credit is due them for the judicious manner in which they have performed their very important duties in the publication. Like credit is due the printers and lithographers for the excellent manner in which they have done their work. The fact that it has been so well executed in our own state is a just source of pride.

The economy of the publication when its character is considered, is something remarkable. The volume, containing 768 closely printed, royal octavo pages, illustrated by 10 colored, and 27 uncolored lithographic plates, and by 121 wood cuts, cost, as shown by the accounts audited in the office of the secretary of state, $2.41 per copy. The atlas of 14 large maps in colors, cost $2.27 per copy. It should be considered that the above includes the cost of procuring stereotype plates, which are now the property of the state, and that the edition was but 2,500 copies, the expense of which is proportionately greater than for a larger edition.

There is at present no specific provision by which parties, not entitled to copies under the specifications of the law, can procure them. A very considerable demand has already been made by such parties, who express a willingness to pay for the publication. As it is manifestly impracticable for the state to extend gratuitous distribution beyond a certain limit, and yet, it is as certainly for its interest to have the work as widely distributed as possible, I would respectfully recommend that the commissioners of public printing be authorized to procure the publication of such additional copies as may be demanded, which shall be placed on sale in a manner analagous to that of the legal publications of the state. As the work is stereotyped and the engraved stones retained, the republication would be inexpensive.

For reasons stated in my last annual report, and in the preface of the book itself, the portion now issued is designated Volume II. The engraving for the maps and illustrations of volumes I and III is already in progress, and the work will be carried forward as fast as its nature will permit. Its execution is entrusted to the same hands, and will be done at the same advantageous rates as in the case of the volume already issued. The terms of the publication of the rest of the report, whether it be more or less in amount, being fixed by contract, the expenses will be determined by what degree of fullness, in the publication of the results of the survey, is desired. In the portion now published, brevity has been assiduously studied, and the data collected have, to a considerable extent, been summarized, rather than presented in full, and, even then, a large mass of details of much local interest has been omitted. A greater degree of brevity could not well be attained, without seriously affecting the thoroughness of the report, and a somewhat greater freedom in

elaboration is desirable. Profuseness of detail in minor descriptions is not, however, considered, by the writer, desirable in reporting, though necessary to thoroughness in investigation, and it is not contemplated in the plan of publication adopted. But, with as great a degree of conciseness as is consistent with a fair presentation of our results, three additional volumes — four in all — will be needed, unless they are made undesirably large, and it is thought that the utmost prudent limit in that direction has already been reached, if not exceeded. The appropriation already made will not be sufficient to complete the two volumes in progress, and an additional provision is needed.

ACCOUNTS.

Full accounts of all expenditures connected with the survey, accompanied by vouchers, may be found on file in the Executive Office. It is believed that they show a highly economical administration of the survey.

ACKNOWLEDGMENTS.

The survey has been greatly indebted during the past year, as heretofore, to numerous citizens, who, by their kind assistance through personal services or valuable information, have greatly aided in its prosecution. To all these, the members of the corps desire to return their warmest thanks.

The survey has been placed under especial obligations to the officers of the Chicago & Northwestern Railway, the Milwaukee & St. Paul Railway, the Wisconsin Central Railway, the West Wisconsin Railway, the Western Union Railway, the Mineral Point Railway, and the Green Bay & Minnesota Railway, who, by very generously granting free transportation to members of the corps, and by other special favors, have facilitated the work and materially reduced its expense.

PRESENT STATE OF THE WORK.

The statute provision that the survey shall be finished by the first of next June, has been accepted in good faith, and the work has been directed with that fact in view, and the energies of the corps have been faithfully devoted to an effort to place the survey in the best practicable condition for closing on that date. The work will

not be, and in view of the extent of the field, its wildness, and its inherent difficulties, could not be exhaustive, with the facilities at our command. Much more valuable work can still be done, especially in the north, and the mining regions. But, recognizing the generosity and confidence of the last legislature in granting, in advance of any published results, an additional year, and, having now presented in published form a typical portion of their investigations, the corps will cheerfully accept the limit imposed upon them, or will execute with equal cheerfulness any additional directions which the legislature may give.

It will be manifestly impossible to complete the publication by next June; indeed, it will require diligent application to elaborate the material collected, by that date, and several months' labor must follow in publication, but this the corps will not hesitate to do without regard to the question of compensation, if the necessary authority is granted them.

PRELIMINARY DESCRIPTIONS OF NEW SPECIES OF FOSSILS FROM THE LOWER GEOLOGICAL FORMATIONS OF WISCONSIN.

BY R. P. WHITFIELD.

Potsdam Sandstone Species.

Palæophycus plumosum, n. sp.

Species consisting of slender and elongated, slightly flattened or cylindrical stems of about a twelfth of an inch in diameter, and somewhat flexuous, dividing and subdividing at the upper extremity into several branches, forming feather-like tufts, the divisions of which almost immediately attain the same dimensions as the parent stem, and are from half an inch to an inch and a half in length. Surface, apparently roughened by indistinct longitudinal corrugations.

The remains, at first sight, somewhat resemble those described in vol. 1, Pal. Foss., Canada, under the generic name *Lycrophycus*,

but when more closely examined, are seen to have an entirely different mode of bifurcation, the divisions being of the size of the parent stem and taking place apparently one at a time, although very near each other, instead of the parent stem breaking up, at once, into a great number of smaller branches.

Formation and locality. In thin, greenish sandstone layers of the Potsdam Period, below Mendota, Wisconsin.

Triplesia primordialis, n. sp.

Shell small, measuring less than half an inch in width; transversely oral in outline, and quite ventricose in profile; hinge-line straight and about half as long as the width of the shell below; area narrow. Ventral valve with a strongly depressed, rather narrow and rounded mesial sinus. Dorsal valve, with a narrow, sharply elevated fold not extending quite to the beak; sides of the valve rounded. Surface smooth in the casts, but presenting the appearance of having been externally striate. Processes in the interior of the dorsal valve, apparently forming a small spoon-shaped pit at the beak.

Formation and locality. In the Potsdam sandstone at Roche-á-Cris bluff, Adams county, Wisconsin.

Palœacmœa Irvingi, n. sp.

Shell rather large, patelliform, about half as high as wide, and the length slightly exceeding the width, giving a broadly oval or ovate outline to the margin; apical half of the shell rather more abruptly conical than the basal portion, the apex situated slightly in advance of the middle of the length and laterally compressed; body of the shell marked by strong, concentric or encircling undulating wrinkles or folds, and also by lines of growth.

The species differs from *P. typica* H. & W., from the Potsdam sandstone of New York, in its greater size, more circular form, compressed apex and stronger undulations. The species appears to have been not uncommon, but as it occurs in a hard quartzitic sandstone it is not readily obtained in good condition, but appears mostly in the form of rings or parts of rings on the surface of the rocks, and is consequently not easily recognized.

Formation and locality. In the quartzite layers of the Potsdam group, in Jackson county, Wisconsin.

Bellerophon antiquatus, n. sp.

Shell small, generally measuring not more than five-sixteenths of an inch in its transverse diameter; globose in form, involutely and closely coiled, leaving but a very narrow aperture, the preceding volution projecting into, and occupying the greater part of its area; auriculations rounded, not projecting beyond the general rotundity of the shell; axis probably imperforate in the perfect condition, but in the cast, in which state they all appear so far as yet observed, it is seen to be minutely perforate, from the removal of the solid axis. Margin of the aperture characterized by a broad, shallow sinus, angular at the center. No appearance of any reflexion or thickening of the margin can be detected. Surface markings not satisfactorily determined; there are, however, on the best preserved individual, faint indications of regular transverse lines parallel to the margin of the aperture, but owing to the friable nature of the sandstone cannot be positively determined.

So far as we know, there has been no species of this type of the genus recognized in rocks of this horizon before, and none with which it need be confounded.

Formation and locality. In soft friable sandstone of the Potsdam group, at Osceola Mills, Wisconsin, associated with other species of the same age.

Conocephalites calymenoides, n. sp.

Species less than medium size, the largest head noticed measuring scarcely three-eighths of an inch in length. The glabella and fixed cheeks, the only parts of the carapace positively identified, present much the general appearance of a species of *calymene.* Glabella proportionally small, not exceeding half the entire length of the head, conical in form and obtusely pointed above, the width across the base rather more than equaling half the length, separated from the fixed cheeks by deep, abrupt dorsal furrows; surface convex, prominent and destitute of glabellar furrows; frontal limb nearly twice as wide between the suture lines as the greatest width of the glabella, its surface elevated into a highly convex, transversely oval boss or tubercle, which is separated from the glabella by a wide, deep furrow; fixed cheeks highly and abruptly elevated and of proportionally large size; palpebral lobes semilunate or

crescentiform, and situated opposite the upper end of the glabella; occipital furrow narrow, but deeply depressed; ring narrow, rounded and prominent. Facial suture nearly straight, in front of the eye lobes to the middle of the tuberosity of the frontal limb, around the front of which it seems to curve; behind the eye it is directed outward for nearly half the width of the lateral limb, where it changes abruptly, forming an obtuse angle, and is then directed outward and backward with a slightly convex curvature to the posterior margin of the head at a point distant from the dorsal furrow about equal to the length of the glabella and occipital ring, forming large, triangular lateral limbs.

The tuberosity of the frontal limb, the large elevated fixed cheeks, deep dorsal furrows and small size are prominent features, and will serve to distinguish it from any known species.

Thorax long and narrow, the length exceeding once and a half the greatest width; regularly and gradually narrowing from the occiput posteriorly, very highly arched transversely and strongly trilobed, consisting of twenty-two or more articulations. Axial lobe forming rather more than one-third of the entire width of the thorax, highly elevated, the curvature quite equaling a semicircle; lateral lobes narrower and deeper than the axial, the sides nearly vertical; dorsal furrows strongly marked; segments very short, the axial portion strongly rounded from front to back; pleura less strongly rounded than the axial portion, the anterior element forming nearly one-half the width at the inner end but decreasing outward, the furrow separating the two portions, deep and extending more than half the length of the pleura, outer portion flattened on the articular surface and rounded on the posterior margin; extremity rounded. Pygidium unknown.

Formation and locality. In sandstone of the Potsdam formation (upper part), associated with *Agraulos Woosteri*, at Eau Claire, Wisconsin.

Crepicephalus onustus, n. sp.

Glabella of moderate size, highly convex, broadly conical and narrowly rounded at the summit, the width at the base equaling the height exclusive of the occipital ring, short, less prominent than the glabella and somewhat narrower; fixed cheeks narrow, rounded and prominent; palpebral lobes small and inconspicuous,

situated opposite the middle of the glabella; frontal limb moderately long and regularly rounded on the margin between the facial sutures, the front margin prominent and rounded, the space between it and the glabella deeply and regularly concave and strongly arcuate laterally; ocular ridges faintly marked; dorsal furrows narrow, very deep and sharply marked; facial suture directed gently outward in its course from the eye-lobes to the anterior margin of the head, but recurving near the edge and slightly rounding the antero-lateral angles of the frontal limb; behind the eye it is directed outward at an angle of about forty-five degrees, with a slight sigmoidal curvature to the posterior margin of the head, forming a short triangular lateral limb; posterior furrows narrow and directed slightly forward in their passage from the dorsal furrows to the suture. Other parts of the organism unknown. Length of the head half an inch; length of glabella from the occipital furrow, nine-sixteenths of an inch.

Formation and locality. In rather compact yellow sandstone of the Potsdam period, at Ettrick, Wisconsin.

Ptychaspis granulosa.

Dicellocephalus granulosus. Owen: U. S. Geol. Surv., Wisconsin, Iowa and Minnesota, p. 575, pl. 1, f. 7.

Not Ptychaspis granulosa. Hall: 16th Rept. State Cab. N. Y., p. 173, pl. vi., f. 33-40.

Glabella elongated, cylindrical or very slightly narrowing anteriorly, highly convex and divided transversely by three pairs of furrows, the two posterior ones being strongly marked and uniting in the middle, and directed forward at the outer extremities; the anterior pair being very short and faintly marked. Anterior extremity of the glabella rounded; dorsal furrows deep and well marked. Fixed cheeks, broad at the eye and widening behind, but in front of the eye are narrowed and rounded to the anterior margin of the head. Eye-lobes small and situated opposite the extremity of the middle glabellar furrow. In front of the eye-lobes and glabella, the fixed cheeks and frontal limb are strongly curved downward to the anterior margin, the frontal limb being of medium width but appearing narrow from foreshortening, as seen in a vertical view.

Surface of the fixed cheeks and glabella covered with coarse, ele-

vated and transversly elongated pustules or granules, of proportionally large size, arranged in indistinct rows on the fixed cheeks, while on the glabella they are less regular and not so prominent.

This species is peculiar, among the Wisconsin forms, for its pustulose surface. The specimens in hand are all fragmentary, that figured being among the most perfect, but lacking the occipital ring and back portion of the fixed cheeks. The movable cheeks associated with the glabellas are also quite imperfect, but show the pustulose characters very distinctly, and corresponding very well with those described and figured by Dr. Owen as above cited; but differing very materially from those identified with that species, by Prof. Hall, in having the surface strongly pustulose instead of lined or striated. We, therefore, purpose to recognize that species under the name *Ptychaspis striata*, from its striated surface features.

Ptychaspis striata, *n. sp.*

Ptychaspis granulosa. Hall: 16th Rept. State Cab. N. Y., p. 173, pl. vi., fig. 33–40.
Not Dicellocephalus granulosus. Owen.

Differs from *Ptychaspis granulosa*, Owen sp., in having the surface of the head strongly striated or marked with elevated ridges, which are more or less parallel to the margin.

Ptychaspis minuta, *n. sp.*

A minute species known only from detached portions of the head; the length of which, as seen on the largest individuals observed, scarcely exceeds one-sixth of an inch, and mostly not more than an eighth of an inch from the anterior margin to the back of the occipital ring.

Glabella cylinderical, rounded and projecting in front, divided transversly by two pairs of deeply marked, oblique glabellar furrows, neither of which extend entirely across, and by a very faint third pair situated near the anterior end; occipital furrows, also deep, the ring narrow and elevated. Fixed cheeks convex, more than half the width of the glabella at the palpebral lobe, widening behind and narrowing in front. Frontal limb narrow and abruptly curved downward in front of the glabella, so as to be scarcely seen

in a vertical view; dorsal furrow deeply marked. Eye lobes proportionally long but very narrow and but slightly elevated.

Movable cheeks elongated-triangular, convex on the surface, extended backwards at the genal angles into short obtuse spines; ocular rims of moderate size. Surface coarsely striated near the margin parallel to the border. Thorax and pygidium unknown.

The small size of the species, with its deeply lobed glabella and abruptly declining frontal limb, when taken with its characteristic form, will readily distinguish the species.

Formation and locality. In soft, very friable, greenish-brown sandstone of the Potsdam formation, at Roberts' Store, St. Croix county, Wisconsin.

Agraulos (Bathyurus?) Woosteri, n. sp.

Head and movable cheeks, when united, semi-circular or short-paraboloid in form, rather strong convex and bordered by a narrow, rounded and elevated rim, which is wider in front than on the sides, genal angles obtusely-rounded and destitute of spine. Glabella round-conical in outline, prominent and convex, two-thirds as wide at the base as the length, including the occipital ring, the surface smooth and destitute of transverse furrows. Dorsal furrows faintly marked, occipital furrow not strongly marked. Fixed cheeks less than half as wide at the eye as the middle of the glabella; frontal limb, from the glabella to the anterior margin of the head, half as long as the glabella and occipital ring, and rapidly sloping from the glabella to the marginal rim. Eyes prominent, proportionally large, reniform and the visual surface strongly convex. Facial suture strongly diverging from the eyes to the anterior marginal rim, through which it passes with a strong inward curvature to the front, the width of the frontal limb being equal to the entire length of the head. Behind the eye the suture passes backward and outward to the posterior margin, at an angle of not more than fifteen to twenty degrees, with the vertical axis of the head.

Thoracic segments not fully determined but those associated on the same sandstone with the glabellas, cheeks, and pygidia are narrow in an antero-posterior direction, and have long, slender and pointed pleura.

Pygidium paraboloid on the outer margin, the anterior margin forming from three to four times as flat a curve as the posterior mar-

gin. Axis highly convex, two-thirds as long as the shield, and not more than one-fourth as wide at its greatest width, marked by four transverse rings, exclusive of the terminal ones; lateral lobes convex, destitute of any thickened border, marked by three furrows on each side, exclusive of the anterior one; ribs simple, and nearly reaching to the border. Marginal selvage of the under surface wide and much thickened.

I know of no species sufficiently resembling this one to be readily confounded with it.

Formation and locality. In yellow sandstone of the Potsdam period (upper part), at Ettrick and Eau Claire, Wisconsin.

Arionellus (*Agraulos*) *convexus*, *n. sp.*

Glabella and fixed cheeks united, strongly convex and somewhat paraboloid in form, length and width nearly equal; anterior margin of the head between the suture lines regularly and somewhat sharply arcuate; palpebral lobes small, not very prominent, situated posterior to the middle of the head. Glabella rather less than two-thirds of the entire length of the shield, rounded conical in form and somewhat abruptly tapering; scarcely defined at the margins by the dorsal furrows, and apparently very indistinctly marked by three pairs of oblique furrows; occipital ring narrower than the base of the glabella, and more prominent, and also extending beyond the posterior limits of the fixed cheeks; occipital furrow very shallow and faintly marked, the ring short in the middle and reduced to its minimum width at its junction with the dorsal furrows. Fixed cheeks, half as wide as the glabella; frontal limb as long in the middle as the width of the fixed cheek, and slightly increasing toward the lateral angles. Facial suture passing nearly direct from the eye to the anterior margin of the head, its direction posterior to the eye not determined.

The largest example of the glabella and fixed cheeks observed, measures about three-fourths of an inch in length by nearly seven-eighths of an inch in width at the base. No other parts of the organism have been observed.

Formation and locality. In brown sandstone of the Potsdam formation, at Ironton, Sauk county, Wisconsin.

Elliptocephalus curtus, n. sp.

This species is known only by several detached portions of the cephalic shield, which occur in sandstone associated with *orthis pepina*, *Ptychaspis miniscaensis* and fragments of other trilobites crowded together, rendering it impossible to satisfactorily determine portions of other parts of the organism. The fragments observed consist of the glabella and fixed checks, which, united, are sub-semicircular in form; the glabella is but slightly elevated, once and a half as long as wide, measuring from the back of the occipital ring, and somewhat quadrangular in shape; the front being almost regularly rounded, the sides parallel and the width less across the middle than in front. A very slight angularity exists along the middle, and a single furrow crosses it near the base, distinct in the middle, but becoming obsolete before reaching the sides.* Frontal limb very short in the middle, gradually and rapidly widening laterally. Fixed-cheeks wide, but little less at the palpebral lobes than the width of the glabella, but rapidly contracting behind to about two-thirds of that width; their general surface flattened or somewhat depressed between the eye and the glabella. Occipital ring narrow; posterior cheek furrow very narrow. Dorsal furrow not impressed below the general level of the fixed-cheek. Facial suture curved inward in front of the eye to the anterior border, and behind, directed inward nearly at right angles to the axis, to a distance equal to one-third the width of the cheek, and then abruptly deflected to the posterior border of the head. Palpebral lobes proportionally large, simple in structure, elevated on the margin and semi-lunate in form, situated very near to the posterior margin of the head.

Formation and locality. — In friable brown sandstone of the Potsdam period.

SPECIES FROM THE LOWER MAGNESIAN LIMESTONE.

The following group of species is of peculiar interest, as coming from a bed of Lower Magnesian limestone occurring within the

* It is possible this may be the occipital furrow, as the ring is imperfect in all the specimens, but this being placed in advance of the furrow of the fixed cheek, has been considered as a glabellar furrow.

area occupied by the Huronian quartzites of the Devils Lake region, at a quarry owned by Mr. Eiky, several miles east of Baraboo.

The bed in which they occur is underlaid by a sandstone of the Potsdam period containing an abundance of Scolithus borings, apparently of the same age, and probably of nearly the same horizon as the sandstone a few miles distant, nearer the lake, from which the fossils described by Prof. A. Winchell in the Am. Jour. Sci. and Arts, March, 1864, were obtained. The outcrop rests within the curve of a quartzite hill, near the eastern end of the range, and at a level considerably below that of the top of the quartzites; while, at a short distance to the northeast, there is an outcrop of sandstone at a considerably higher level than these magnesian beds.

The fossils are all new, except the *Leptæna*, of which there was but one specimen obtained, and are of peculiar types. Some of the trilobites are similar to those described by Mr. Billings, Pal. Foss. Can. Vol. 1, p. 409, under the generic name *Bathyurus*, but are of different species, and are, we think, clearly referable to the genus *Dicellocephalus*, rather than to *Bathyurus*, as exemplified by the type of the genus *B. extans*, Hall sp. The occurrence of a species of the genus *Illænurus* shows the intimate relations which existed between the fauna of this and of the preceding Potsdam period of the neighboring counties.

The existence of several species of *Metoptoma* of peculiar character, and also of the new and remarkable genus *Scævogyra*, adds a very marked feature, and gives a peculiar interest to the fauna of this very limited deposit. The rather remarkable fact that all the spiral shells found at this locality are sinistrally coiled, and that two, at least, of the capuloid forms show a tendency toward a backward curving at the apex, gives a peculiar interest to the entire fauna, and makes it particularly desirable that these beds should be more thoroughly explored.

Beyond the species here described, a single specimen of a rather peculiar species of *Stromatopora* was found loose, near the top of the quarry; but showing marks of abrasion to such an extent as to suggest that it might have been derived from some other locality; although the lithological features would indicate it as belonging here. Still, with this uncertainty, we have not considered it safe to refer it to this horizon, although of an undescribed species.

Leptæna Barabuensis.

Orthis Barabuensis. Winchell: Am. Jour. Sci. and Arts, Vol. 37, 1864, p. 228. Extract p. 4.

A single specimen of a ventral valve only was obtained. The shell is half as wide again as high, with a narrow, linear, nearly straight hinge-line and area, not quite as long as the shell below in the specimen used; the extremeties being rounded and forming with the front line nearly two-thirds of an oval figure. Surface of the valve convex, with a distinct median sulcus, somewhat angular in the bottom, and passing from beak to base. The surface also gives indications of having been marked by faint radiating striæ.

The specimen under consideration differs from those obtained from the sandstones below, in being less angular in the sinus, and less extended along the hinge-line; but these differences are not sufficiently marked to be considered of specific importance when seen on only a single individual valve. The species was originally described as an *Orthis*, but is, we think, clearly referable to *Leptæna*, and we have, therefore, thus placed it.

Metoptoma Barabuensis, n. sp.

Shell rather large, ovate in general outline on the margin; apex highly elevated, pointed, and directed forward even beyond the limits of the anterior margin of the aperture, attenuated in the upper part, and on one specimen, having the appearance of being slightly recurved at the tip; elevation of the apex equal to, or greater than half the length of the shell measured along the base. Anterior slope vertical, slightly concave or somewhat overhanging, sometimes with a slight angularity along the median line from the apex to the margin; lateral slopes slighly convex; posterior slope most strongly rounded. Surface of the shell marked by concentric lines of growth, and on the posterior and lateral slopes, very faint indications of fine radiating lines are observable.

This species is most nearly related to *M. Nyctcis* (Bill. Pal. Foss. Canada, Vol. 1, p. 37, Fig. 39), than to any other described species, but differs materially in the more erect form and greater elevation of the apex.

Metoptoma recurva, n. sp.

Shell rather large, ovate in general outline, apex highly elevated with a strongly backward curvature throughout its length; anterior slope very abrupt and slightly convex; subangular along the median line from beak to base; posterior slope broadly concave, and the lateral slopes nearly direct; apical portion of the shell unknown, the specimen being imperfect in this part. In the earlier stages of growth the shell has been very moderately expanding at the margin but increased rapidly in height; afterwards becoming more rapidly expending, especially around the posterior margin, giving a long concave posterior slope, broadly curved and almost flattened near the posterior margin, while the anterior portion retains its vertical character. Surface marked by concentric lines of growth, strongest where crossing the angularity of the anterior end; also by faint evidence of obscure radiating lines.

This species differs from all others described, and is peculiar for the strong recurving apical portion, the convex anterior slope and broadly concave posterior slope.

Metoptoma similis, n. sp.

Shell of medium size or smaller, elongate-oval or slightly elliptical in outline, two-thirds as wide as long, depressed-convex on the top, the umbro slightly elevated and the beak depressed almost to the level of the anterior basal margin; greatest convexity at the anterior third of the length and not exceeding one-half the width of the shell. Anterior end very short, angular along the median line, and the slope concave; apex and anterior half of the dorsal slope angular or subcarinate in the middle, becoming more regularly rounded posteriorly, antero-lateral slopes slightly concave. Surface unknown.

Scævogyra, new gen.

Thin univalve shells, sinistrally coiled, with a more or less elevated spire, composed of rounded volutions, and characterized on the lower side by a broad, open umbilicus, entirely destitute of callus; peristome entire, uniting with the preceding volution on the inner side, and more or less spreading or trumpet-shaped externally. Types *S. Swezeyi* and *S. elevata.*

The marked peculiarity of the shells for which the above genus is proposed, consists in their sinistral character and open umbilicus. We had at first supposed the former species could be classed under the genus *Maclurea*; but the rounded *naticoid* character of the spire was an objection, and when, on developing the second species from the matrix, the greater elevation of the spire was observed, it was seen at once to indicate an entirely distinct genus. The genus differs from *Maclurea* in the elevation of the spire, rounded volutions and expanded aperture. The appearance is that of a *naticoid* shell of the type of *Gyrodes*, Conrad. They also resemble some forms of *Platyostoma*, Conrad, except in the wide umbilicus and sinistral curvature. We are inclined to think from the character of the shells that they may have been *Heteropodous* rather than *Gasteropodous*.

Scævogyra Swezeyi, n. sp.

Shell of moderate size, depressed convex on the upper side, the spire rather low and composed of about three rounded, rapidly enlarging, sinistrally coiled volutions, the last one more rapidly expanding and becoming distinctly trumped-shaped at the margin of the aperture on the upper side; suture line distinct in the casts; umbilicus wide and open, subangular at the margin, and the depression abrupt. Aperture oblique, strongly receding below; section of the volution obovate, widest above and angular below, somewhat modified at the inner upper portion by the preceding volution. Surface marked by distinct lines of growth, and in some cases by slight undulations of the shell parallel to the margin of the aperture.

The shell is peculiar for its distinctly naticoid appearance in all respects except the sinistral curvature of the spire.

Scævogyra elevata, n. sp.

Shell of medium size, the largest specimen observed measures a little more than an inch in height, spire proportionally elevated, the apical angle being about thirty-eight to forty degrees. Volutions sinistral, about three in number, moderately increasing in size and strongly rounded on the surface; suture line distinct; umbilicus only moderately wide, less than half the diameter of the volution. Aperture semilunate in form, straightened on the inner side and slightly modified above by the preceding volution; outer

lip slightly expanded at the margin on the outer portion. Surface of the shell, so far as can be observed in the matrix, destitute of markings.

The great elevation of the spire of this species and the smaller umbilicus are distinguishing features.

Scævogyra obliqua, n. sp.

Shell, sinistral, very oblique; consisting of about two volutions, the outer one forming nearly the entire bulk of the shell, rapidly descending in its curvature and somewhat compressed on the outer surface. Section of the volution elongate-ovate, somewhat constricted on the inner side and very slightly modified, at the upper inner angle, by the preceding volution. Aperture very much elongated, somewhat rounded below; umbilicus small; suture line indistinct. Surface of the shell unknown.

The species is readily distinguished from the others by the proportionally large body volution, the upper one being only apical. A single specimen only, was obtained, having been discovered and presented by Mr. Miller, of the class of "77," Beloit College.

GENUS DICELLOCEPHALUS — OWEN.

The two following species of *Dicellocephalus* are of great interest from the fact that they preserve the true form and convexity of the carapace, showing them to be quite convex and rotund. Nearly all the species of this group of Trilobites hitherto described have been obtained either from soft, compressible sandstone, from sandy shales, or from shaly rocks, where the objects have been subjected to much distortion or change in form by vertical compression, flattening or spreading out the crust so as to present broad, flattened objects of but slight convexity; but in the present case the matrix is a hard and very unyielding magnesian limestone, which has perserved them in their true proportions, although, as in nearly all other cases with species of this genus, they are preserved only as detached fragments, or parts.

Dicellocephalus Barabuensis, n. sp.

Entire form of body unknown, the species being recognized by the glabella and fixed cheeks, united by detached, movable cheeks

and isolated pygidia. The species has attained to a medium size, the heads sometimes measuring one inch or more in length from the anterior border to the base of the occipital ring. Glabella strongly arcuate, longitudinally, and somewhat less so transversely, separated from the fixed cheeks by well marked dorsal furrows, which are continued in front; sides of the glabella, very gradually converging anteriorly; anterior end, rounded surface marked by two pairs of very faint furrows, the anterior pair often obsolete, and the posterior seldom extending to more than one-third of the distance from the dorsal furrow, recurved at the inner end; occipital furrow broad and distinct, but not deep; occipital ring large and strong, widening in the middle posteriorly. Fixed cheeks, very narrow; palpebral lobes, small, obtusely angular in the middle, moderately prominent, and situated opposite the middle of the length of the glabella. Frontal limb wide and short, bordered by a distinctly elevated, flattened, narrow anterior rim; posterior lateral limbs, narrow longitudinally, but as long laterally as the width across the middle of the glabella, deeply and broadly furrowed sutures cutting the anterior border nearly on a line with the outside of the eye lobe, which they reach with a slightly outward curvature, and behind are directed strongly outward at a low angle with the line of the base of the head.

Movable cheeks, porportionally large, depressed convex, on the surface, and nearly semicircular in outline, margined by a moderately wide, thickened, slightly elevated rim, which is prolonged in an acute spur on the anterior extremity, and incurved at the genal angles, not prolonged in the form of spines.

Pygidium, referred to the species, subelliptical in outline, the marginal curve forming nearly one-third of a circle, while the anterior border is much less strongly arched; length and breadth as three to five, and the lateral angles slightly rounded; axis strong, forming fully one-third of the entire width, strongly elevated, and a little less than two-thirds of the entire length of the plate, marked by three rings, exclusive of the anterior one. Lateral lobes convex, destitute of a thickened border, and marked by three very obscure ribs on each side, not observable on all the specimens.

The species somewhat closely resembles *Bathyurus capax* (Bill. Pal. Foss., Canada, Vol. 1, p. 409, fig. 389), but is more convex, has narrower fixed cheeks and more distinct glabellar furrows that one being described as destitute of them.

Dicellocephalus Eatoni, n. sp.

Entire form unknown. Glabella and fixed cheeks, when united, quadrangular in form, and very convex as seen uncompressed in the limestone; entire length of the head equalling the breadth across the palpebral lobes. Glabella, quadrangular, widest at the base, gently narrowing to the front, slightly rounded at the antero-lateral angles, and squarely truncate on the anterior border, where it is rather more than two-thirds as wide as at the occipital furrow; separated from the fixed cheeks by shallow dorsal furrows, as well as by its greater convexity. Surface of the glabella marked by a broad and very shallow, but poorly defined posterior furrow, which is strongly directed backward in the outer portions, but nearly straight in the middle; and on a single example, by a very faint pair just in front of the eye lobe. Fixed cheeks narrow, not at all prominent. Eye lobes moderately large, prominent on the anterior end and much less so posteriorly. Frontal border, wide, measuring on the most perfect specimen, about three-eighths of an inch between the front of the glabella and the anterior margin, strongly striated transversely with coarse, distant striæ. Suture line, as shown by the outline of the fixed cheeks, directed slightly outward in front of the eye, and rounding inward in crossing the anterior border; posterior to the eye its course has not been determined. Posterior lateral limb unknown, but from the position of the eye, has evidently been narrow, and, from the form of the movable cheek, quite extended laterally.

Movable cheeks large, strong, subtriangular in outline strongly convex, with a large ocular sinus, and a wide, thickened, and strongly striate marginal border, which gradually narrows posteriorly to the genal angle. The anterior margin is prolonged in a spine-like projection, corresponding to the rounding of the antero-lateral angle of the frontal limb.

A large, semicircular or elliptical caudal plate, which may be the pygidium of this species, was discovered among the specimens obtained at the quarry, after reaching home. The length is less than half the width, the surface regularly convex, with a short and proportionally small axial lobe, about half as long as the shield, and with indications of faint rings.

The posterior margin is regularly and symetrically rounded

throughout, and the curvature considerably shorter than that of the anterior margin. It is possible this may be the caudal shield of the above species, although from the character of the head and its great resemblance to *D. Minnesotensis*, Owen, we had expected a somewhat different shaped plate.

Illænurus convexus, n. sp.

Glabella and fixed cheeks, as seen united, round conical in outline, half as wide again at the base as in front of the eyes. Surface almost regularly and equally convex, and destitute of either dorsal glabellar, or occipital furrows, except the former, which are represented very faintly near the posterior margin by slight indentations, and by the construction of the posterior margin of the head. Posterior margin of the glabella strongly rounded backward beyond the line of the lateral limbs; ocular lobes inconspicuous, and situated near the middle of the length of the head; lateral limbs short triangular; anterior border of the frontal limb rounded between the suture lines, as if the movable cheeks had united in front. Facial suture very simple, being rounded inward in front of the eye, and behind is directed backward and slightly outward, with a gently sigmoid curvature, to the occipital border, at a distance from the dorsal furrow equal to one-fourth the width of the glabella.

Movable cheeks not definitely determined. There is, however, a single example of a cheek in the collection which may possibly belong to this species, although the thickened rounded border would seem to be an objection to this view. The suture line of the specimen, as shown on its border, corresponds nearly to that of the above described head, when held in a corresponding position. The specimen is rather strongly convex with a thickened rounded margin of moderate width, the anterior prolongation of which has been broken, while the posterior angle is prolonged into a short curving spine having a downward direction.

Pygidium, elliptical, twice as wide as long, strongly convex on the surface, pointed at the lateral angles and less arched on the anterior than on the posterior margin, with slight constrictions at the place of the dorsal furrows.

Euomphalus Strongi, n. sp.

Shell somewhat larger than medium size, subdiscoidal, and coiled

nearly in the same plane, the depression of the spire being nearly as great as the depth of the umbilical opening. Volutions, three or more, rapidly increasing in size and very slightly overlapping each other on the upper surface, strongly convex on the sides, becoming obtusely subangular just within the middle of their width and sloping rapidly in each direction from this point; dorsum rather more decidedly subangular than the sides, giving a somewhat subquadrangular form to the volution when seen in a transverse section. Surface of the shell indistinctly marked by broad faint undulations, parallel to the margin of the aperture, and having a strong backward curvature from the ventral to the dorsal angles, indicating a deep angular notch-like feature of the margin.

This is a very neat and pretty species, presenting in its almost symmetrically coiled volutions, much the character of a large species of *Cyrtolites*, but on close examination it is seen to be spirally coiled, although but very slightly off the plane of the volutions. The diameter of the largest individual is nearly two and one-fourth inches, with a transverse diameter of the volution at the aperture of about three-fourths of an inch.

Formation and locality. In cherty layers of the Lower Magnesian limestone, Richland county, Wisconsin. Named in honor of the discoverer, Moses Strong, Esq.

Species from the Trenton Group.

Trematopora annulifer, n. sp.

Bryozoum forming slender, solid branches, with a diameter in the larger specimens of nearly a line, and marked by distant bifurcations. Branches characterized by numerous encircling annulations which are arranged at about a sixteenth of an inch from each other, and are angular on the crest with concave interspaces. Cell-pores very minute, elongate polygonal in form, two-thirds as wide as long, and separated by intercellular spaces somewhat narrower than the cells, and deeply grooved along the middle, leaving an elevated margin bordering the cell aperture, which is elevated at the base to form a short triangular node or spine.

The species is peculiar in its regular encircling annulations placed at about the same distance from each other on specimens of all diameters. The cell-pores vary considerable in size and form in dif-

ferent individuals, sometimes occurring nearly circular. The spine at the base of the cell aperture is not always developed, although generally present. The fragments seen vary from one-fourth to nearly one inch in length and are seldom seen to bifurcate, although several have been noticed snowing this feature.

Formation and locality. In shales of the Hudson river formation at Delafield, Wisconsin.

Trematopora granulata, n. sp,

Bryozoum growing in strong, solid bifurcating branches, which are marked with low, rounded distant nodes, and the entire surface densely covered with small, rounded, elliptical, or quadrangular cells, the apertures of which are slightly excavated and divided by proportionally thick partition walls. Surface of the partition walls thickly set with small, rounded granules, sometimes arranged in a single and sometimes in a double series, from nine to twelve granules may be counted around a single cell where they form only a single series, but where a double series exists they often alternate, so that the nodes are more distant. Cells, where counted in a direct series, numbering from twelve to fourteen in the space of an eighth of an inch.

The growth of the cells is generally from the centre outward, forming solid branches, with the cell opening at right angles to the axis; instances occur, however, where the upper end of a branch is hollow, the cells forming oniy a thin crust or tube, this, however, is not the usual mode of growth, but, apparently, the result of accident. In some of the cells, thin, distant diaphragms can be seen. Intercellular substance, apparently solid.

There is no species described from rocks of this age, which sufficiently resembles this one to require comparison.

Formation and locality. In shales of the age of the Hudson river formation, at Delafield, Wisconsin.

Fenestella granulosa, n. sp.

Bryozoum, growing in small fan-shaped or funnel-formed fronds, which rise from a root-like base, by which they have been attached to foreign substances. Longitudinal rays slender, rather closely arranged, and frequently bifurcated; giving to the lower part of the frond a somewhat irregular mode of growth, but becoming more

regular above. From three to four of the rays may be counted in the space of one millimeter, in the upper part, but seldom more than three in the lower. Fenestrules subquadrangular, longer than wide, but extremely variable in size and form, and about as wide as the diameter of the rays. Pores small, slightly oval, scarcely excert, generally four to each fenestrule, one of which is situated at the junction of the transverse dissepiment; rays carinate between the pores; dissepiments narrower than the rays. Non-poriferous surface of the rays convex, distinctly but very minutely granulose, the granules closely and irregularly arranged, sometimes numbering as many as six in the width of the ray opposite the fenestrule.

Formation and locality In shales of the Hudson river group, at Delafield, Wisconsin.

Fistulipora solidissima, n. sp.

Bryozoum, forming strong, cylindrical, ramifying branches, which often attain a diameter of nearly one-fourth of an inch. General surface destitute of tubercles or tuberculiform elevations, but densely covered with minute, elongate-oval, or sometimes rounded cell-pores, which are separated by intercellular spaces as wide or wider than the transverse diameter of the pores. Intercellular spaces marked, usually, by a single series of very minute, slightly elongated, polygonal pits, which vary in size according to their positions; being largest in the angles formed by three adjacent cells, and smallest on the sides between two nearly opposite cells. Occasionally there are two irregular lines of pits on the intercellular spaces, but this feature is not a common one. Twelve to sixteen cell-pores may be counted in the space of an eighth of an inch, measured along the branch, and from three to five of the intercellular pits occur in the length of a cell.

Formation and locality. In shales of the Hudson river formation, at Delafield, Wisconsin.

Fistulipora lens, n. sp.

Corallum, growing in small, discoid or plano-convex button-shaped bodies, which appear to have commenced their growth on a fragment of shell or other substance, and afterward become free; discs varying in size from one-fourth, or less, to nearly three-fourths of an inch in diameter. Under surface more or less concave, not

usually possessing an epitheca, but presenting a fine, radiately striate surface, from the exposure of the cell tubes. Cells radiating from an imaginary center, and forming on the upper surface of the disc extremely minute, rounded or polygonal apertures, with often a thin sharp partition wall, but more frequently the wall has a thickness of nearly half the diameter of the cell, with one large intercellular pit, occupying the space between the adjacent cells, and other smaller ones between the cells, wherever the walls are thick enough to permit them. The walls near the angles between the cells, bear small elevated points or nodes, in many or most cases, as seen when looked at obliquely, under a strong lens. Four of the cells occupy the space of one millimeter.

Formation and locality. In the shales of the Hudson river group, at Delafield, Wisconsin.

Chætetes fusiformis, n. sp.

Corallum, forming small, solid, irregularly fusiform or sub-cylindrical bodies, which are generally slightly curved, and vary from one-fourth of an inch to one inch in length, and attain a diameter of nearly an eighth of an inch at the thickest part of the larger individuals; extremities usually pointed, generally acute when perfect. Surface covered by very minute, round or slightly oval cell-pores, which are separated by intercellular spaces of from less than one-third to nearly or quite two-thirds of their own diameter, and marked by a few scattered intercellular pits, or a depressed groove, or oftentimes is elevated along the middle, becoming ridge-like, leaving the cell-apertures spreading or excavated.

Formation and locality. In shales of the Hudson river formation, at Iron Ridge, Wisconsin.

Monticulipora rectangularis, n. sp.

Corallum compound and ramose, the stems cylindrical and solid, with distinct bifurcations and often attaining a diameter of three-eighths of an inch. Surface thickly covered with closely set, moderately elevated, rounded tubercles. Cell-tubes of moderate size, from ten to fourteen occupying the space of an eighth of an inch; generally quadrangular in form, though commonly polygonal; usually arranged in concentrically curved rows, diverging from the center of a tubercle or forming segments of circles around them

on the upper side. Cell walls very thin and sharp, not elevated to form spines at the angles.

Formation and locality. In shales of the Hudson River group, at Delafield, Wisconsin.

Monticulipora punctata, n. sp.

Corallum forming comparatively strong, solid, bifurcating branches, varying from an eighth of an inch to more than half an inch in diameter, and attached by the base to foreign substances by a spreading, root-like expansion. The branches are densly covered by medium sized, moderately elevated, not confluent tubercles, which usually measure about a line, or a little more than a line, from center to center; or, if measured in a direct series, numbering from ten to twelve in the space of an inch. The entire surface of the branch, except the top of the tubercles, is marked by fine rounded pits or pores of a nearly uniform size, divided by thickened walls, often slightly flattened on the edge; the pores number from six to twelve between the tubercles. The area on the top of the tubercles not occupied by pores is irregular in form, about one-fourth to one-third of a line across, and is marked by fine, closely arranged puncta, which forms a distinctive character of the species.

Formation and locality. In soft shale of the Hudson river formtiod at Delafield, and also at Iron Ridge, Wisconsin.

Monticulipora multituberculata, n. sp.

Corallum growing in strong, solid, more or less flattened stems or branches, with frequent and irregular bifurcations. Surface of the stems covered with rather strong and prominent, rounded tubercles with concave inter-spaces. Cells of medium size, polygonal in form, and numbering from ten to fourteen in the space of an eighth of an inch, those situated on the tubercles not differing materially from those on the inter-spaces. Cell-walls thin and sharp, without any appearance of inter-cellular pits or pores, and elevated at the angles of the cells to form low points. Cell-tube divided by transverse partitions, which in the outer part are placed at distances about equal to the diameter of the tube.

Formation and locality. In shales of the Hudson river formation at Delafield, Wisconsin.

Alveolites irregularis, n. sp.

Corralum forming solid, flattened branches of irregular form, or incrusting other substances and partaking of the form of such bodies. Cells minute, from twelve to fifteen in the space of a tenth of an inch, more or less rhombic in form, moderately recumbent and diverging from imaginary centers; the posterior lip slightly elevated and acutely angular. Surface often marked at irregular distances, usually of a tenth of an inch or more, with indistinct maculæ, composed of a few cells having thicker walls and somewhat more elevated than the intermediate ones.

Formation and locality. In greenish shales of the Hudson river group, at (151) Wisconsin.

Hemipronites Americana, n. sp.

Shell of medium size, subparaboloid or subquadrangular in outline, hinge-line straight, and as long as the width of the shell below, the sides of the shell somewhat straightened and the front rounded or round-truncate. When viewed in profile the form is plano-pyramidal, the dorsal side flat or even depressed along the middle with a narrow or linear area. Ventral valve pyramidal, half as high as long and having a small, pointed and slightly incurved beak. Area high, with a large closed deltidium. Surface of the shell marked with fine radiating striæ, which are crossed by strong concentric lines of growth at irregular intervals.

Formation and locality. In the upper portion of the Trenton group (Galena horizon), at Flintville, Wisconsin.

Strophomena Kingi, n. sp.

Shell larger than medium size, measuring two inches along the hinge in full grown specimens. Valves strongly concavo-convex, approaching sub-hemispherical on the ventral side with a full rounded umbo, length and breadth sub-equal, or often wider than long; hinge line as long or longer than the shell below, and generally somewhat pointed at the extremities. Area narrow on each valve, that of the convex-valve the largest and marked in the middle by a broadly triangular foramen. Valves rather strongly recurved or deflected near the hinge extremities, so as to give a strongly sinuous hinge-line as seen in a cardinal view. Dorsal

valve deeply concave, closely following the curvature of the ventral. Surface of both valves marked by very fine, even, thread-like or wiry striæ, without any indication of alternation. These are crossed by finer concentric rugose markings invisible to the unassisted eye, and also by fine, indistinct and interrupted concentric undulations on each valve.

Formation and locality. In shales of the Hudson river formation, at Delafield, Wisconsin.

Rhynchonella perlamellosa, n. sp.

Shell of medium size, triangularly-orbicular or very broadly ovate in outline, and lenticular to ventricose in profile; beak small, flattened and closely incurved; cardinal slopes convex and full, never depressed or excavated. Dorsal valve with a moderately elevated mesial fold extending nearly to the beak, and the ventral with a corresponding sinus. Surface marked by strong, simple, subangular plications, four of which are elevated to form the fold and three depressed in the sinus, while from six to eight occur on each side of the shell; plications crossed by rather coarse, distant, strongly lamellose lines of growth, strongly arching backwards in crossing the plications, and continuing across the cardinal slopes to the margin of the shell with but slight diminition in strength.

Formation and locality. In soft shales of the age of the Hudson river group of New York, at Delafield, and also at Iron Ridge, Wisconsin.

Cypricardites megambonus, n. sp.

Shell of medium size, very oblique, ovate in outline and very ventricose in profile, with large tumid, obliquely enrolled beaks, situated a little anterior to the center of the hinge, and strongly projecting above the cardinal line. Valves very deep and very ventricose along the prominent and obtusely rounded umbonal ridge, with a broad, abrupt and slightly concave cardinal slope, and convex, but rapidly declining antero-basal surface; anterior end rapidly sloping backwards, uniting imperceptibly with the basal curve; posterior margin extending obliquely backwards from the extremity of the short hinge line to the postero-basal angle. Surface marked by irregular concentric lines of growth. Hinge plate marked by two or three short, oblique cardinal teeth, and by two

long, curved posterior teeth in the right valve, as shown by the internal cast; muscular imprints rather faint; ligumental area rather small.

Formation and locality. In the Buff limestone of the Trenton group in the upper part of Carpenter's quarry, and also more abundantly at Hess' quarry, near Beloit, Wisconsin.

Metoptoma perovalis, n. sp.

Shell of medium size, oval or elongate-oval in outline, a little more than half as wide as long and about one third as high as the greatest width. General surface depressed convex; anterior end very slightly truncate from below the apex to the anterior margin, giving a slightly flattened and concave anterior slope. Apex small, situated very near the anterior end and slightly overhanging the anterior slope. Surface of the shell smooth so far as can be determined from the specimens in hand.

On the internal cast, the muscular scar is seen as a narrow, scarcely elevated band passing just below the apex on the anterior side, and extending back to near the middle of the length, where it widens and forms a broader band around the posterior half of the cast, at about midway between the apex and the posterior margin. Length of the largest specimen nearly one and one-fourth inches.

Formation and locality. In the lower part of the Lower Blue limestone of the Trenton group, below Carpenter's quarry, Beloit, Wis.

Trochonema Beloitensis, n. sp.

Shell moderately large, with a rather low spire, the entire height of the specimen being somewhat less than the diameter across the base. Volutions about three in number, ventricose, about as high as wide, the outer one increasing in size more rapidly than the preceding, obscurely flattened on the periphery, slightly concave above, and rounded below and on the inner and basal surfaces; suture line very distinct and well marked. Base of the shell gradually rounding into, and forming a deep umbilical cavity, with a rather small central perforation. Aperture rounded and very oblique, not modified by the preceding volution, but apparently having the outer lip slightly expanded. Surface of the cast marked by obscure transverse lines, indicating stronger lines of growth, parallel to the margin of the aperture.

Formation and locality. In the Buff limestone of the Trenton group, at Hess' quarry, near Beloit, Wisconsin.

Clisospira accidentalis, n. sp.

Shell small, sinistrally coiled, spire conical, the apical angle being nearly ninety degrees; volutions from two to two and a half, flattened on the back in the direction of the apical angle, or very slightly convex between the suture lines, and sharply angular on the periphery. Suture distinct on the internal cast, the only condition in which the species has been observed. Base of the shell concave, base of the volution, between the edge of the shell and the axis, very slightly convex, and the axis in the cast minutely perforated, but probably solid in the perfect state. Surface of the cast marked with indistinct undulations, representing lines of growth, which pass rapidly backward, with a broad gentle curvature from the suture to the basal angle; traversing about one-third of the volution between the two points, and indicating a very oblique aperture.

Formation and locality. In the Buff limestone of the Trenton group at Carpenter's quarry, Beloit, Wisconsin.

Maclurea cuneata, n. sp.

Shell of medium size, attaining a diameter of three inches, and consisting of two or more volutions, which increase very rapidly in size; lower (?) side of the shell flat or very slightly concave between the suture-lines; the opposite side being depressed conical between the outer margin and the central depression, with a very slight convexity of the intermediate surface; outer margin of the volution sharply cuneate; central depression very small in the casts, leaving but little more space than would be occupied by the thickness of the shell. Transverse section of the volution triangular.

Formation and locality. In the upper portion of the Trenton group (Galena limestone), at Whitewater, Wisconsin. I have also seen a similar specimen from the same horizon at Dubuque, Iowa

Maclurea subrotunda, n. sp.

Shell rather below the medium size, attaining a diameter of only about one and a half inches, and composed of two very rapidly

increasing volutions, which are almost twice as high as wide; the outer one being nearly vertical on the periphery as it approaches the aperture, and then rapidly rounding on the base and to the very small central depression. Lower (?) surface of the volutions flattened, the two volutions being on the same plane. Surface of the shell not determined.

Formation and locality. In the upper portion of the Trenton group (Galena limestone), at Whitewater, Wisconsin.

Bellerophon Wisconsinensis, n. sp.

Shell of medium size, rather closely coiled, globular in form when young, but becoming strongly bilobed and the lip laterally expanded in the adult form; anterior margin of the aperture broadly and deeply sinuate, and more deeply notched in the middle; periphery of the outer volution marked by a broad, somewhat elevated, and flattened, or slightly convex revolving band, extending along the sides of the deep notch in the aperture. Umbilicus small but in the cast showing of medium size from the removal of the substance forming the axis. Surface of the shell apparently marked by concentric lines of growth parallel to the border of the aperture.

Formation and locality. In the blue beds of the Trenton limestone below Carpenter's quarry, near Beloit, Wisconsin.

Bucania (Tremanolus?) Buelli, n. sp.

Shell of moderate size, composed of from three to three and a half closely coiled, appressed volutions, the last one of which is somewhat more ventricose than the preceding, and broadly expanded or trumpet-shaped at the aperture. Transverse section of the volutions broadly elliptical or reniform, the lateral margins obtuse or subangular, and the ventral surface slightly concave from close contact with the inner coils; the lateral diameter varies from once and a half to nearly twice the dorso-ventral diameter in different parts of the shell. Umbilical openings broad and deep, exposing all the inner coils; suture between the volutions sharply marked. Aperture circular or subcircular, slightly notched in front and moderately elevated along the middle on the exterior; the posterior side slightly modified by the intrusion of the preceding volution. Dorsal surface of the last volution marked by a long, nar-

row slit or opening, extending along the outer half of the whorl and reaching to within about half an inch, more or less, of the margin of the aperture, the edges of the slit being slightly elevated above the surrounding parts of the volution.

Surface of the outer volution marked by raised revolving lines, which originate in fine striæ on the smaller parts of the volution, and rapidly increase in strength toward the aperture; where they become strongly developed and distinctly alternate in size. There are also finer concentric striæ crossing and cancellating the revolving lines.

Formation and locality. In the Upper Buff limestones of the Trenton group, at Hess' quarry, near Beloit, Wisconsin.

Hyolithes Baconi, n. sp.

Shell of moderate size, measuring from one inch to one and a half inches in length, with a diameter at the aperture from one-fourth to one-third of the length. Dorsal side of the shell depressed convex, more abruptly rounded near the margins and on the edges, the surface marked by transverse striæ which arch gently forward and are parallel to the margin of the dorsal extension; dorsal projection regularly rounded and one-third as long as the width of the aperture. Ventral surface about twice as deep as the dorsal, strongly subangular along the middle and the surface marked by transverse striæ which are directed nearly straight across the shell. Transverse section of the tube subtriangular or triangularly elliptical.

Formation and locality. In the harder bluish buff layers of the Trenton group, below Carpenter's quarry, near Beloit, Wisconsin.

Orthoceras (Actinoceras) Beloitense, n. sp.

Shell large and robust, subfusiform, moderately expanding to the diameter of about four inches, then more gradually decreasing in size to the aperture. Section oval in all the examples noticed, and usually a little more flattened on one side than on the other, with the siphuncle submarginal on the flattened side. Septa shallow and not often symmetrically arranged, from seven to eight chambers occupy a length equal to the diameter of the largest of the number measured; toward the outer portion of the shell the septa become more crowded, and just below the outer chamber are some-

times less than half the usual length. Siphuncle large, strongly beaded within the chambers, with an inner core, in the casts, having radiating filaments extending to the center of the bead in each chamber. Surface of the shell unknown.

Formation and locality. In the Trenton limestone (Buff beds), at Hess' quarry, near Beloit, Wisconsin.

Gyroceras duplicostatum, n. sp.

Shell rather small, seldom exceeding two and a half inches across the coil; consisting of one and a half to two or more slender, moderately increasing, loosely coiled volutions, which are not in contact and gradually increase in distance with the increased growth of the shell. Section of the shell circular and of from half an inch to five-eighths of an inch in diameter at the end of one and a half volutions. Surface of the shell marked by closely arranged, sharply elevated, rounded encircling costæ, with wider interspaces, which are mostly occupied on the dorsal half of the shell by smaller additional or intercalated costæ, not extending beyond the middle of the side; costæ bending slightly backward in crossing the side of the volution from the inner to the outer surface, and strongly arching forward in crossing the dorsum.

Formation and locality. In the Trenton limestone at Bristol, Dane county, and in the bluish-buff beds below Carpenter's quarry, near Beloit, Wisconsin.

SPECIES FROM THE NIAGARA GROUP.

Favosites occidens, n. sp.

Corallum, growing in hemispherical or irregularly formed masses of medium size, which are composed of two kinds of cells, the one larger than the other; the larger cells being scattered through the corallum at somewhat irregular intervals, with from one to three of the smaller cells between. Large cells, more or less circular in form, and usually measuring from a sixteenth to a tenth of an inch in diameter. Smaller cells, variable in form and in size, may be observed from minute to more than two-thirds that of the larger form. Transverse diaphragms complete, closely arranged or distant more than the diameter of the tube, in the same individual. Mural pores apparently arranged in single rows, but not very distinctly

observed, owing to a deposit of minute crystals of dolomite on the walls of the cells.

Formation and locality. In the upper part of the Niagara group (Guelph horizon) near Ozaukee and elsewhere in Wisconsin. It is not exclusively confined, however, to this horizon, but occurs sparingly, as small individual masses, in the upper part of the true Niagara formation. at several localities in the state.

Syringopora infundibula, n. sp.

Corallites growing in large or medium sized masses, of variable form, but generally irregularly sub-hemispherical; the individual polyps slender, subflexuose, and measuring from one to nearly two lines in diameter, arranged at distances of from one to three times their own diameter from each other, with small, slender, rounded and distant connecting filaments; logitudinal rays or lamellæ entirely obsolete; transverse diaphragms deeply funnel-formed, appearing as a series of inverted cones placed one within the other, their centers extending downwards and forming by their union with each other a continuous columella-like body. The plates are so closely arranged that from two to four of them may be counted in a space equal to the diameter of the corallite. The external surface of the tube has not been observed.

Formation and locality. In the upper part of the Niagara group (Racine limestone) at several points in the vicinity of Milwaukee, Wisconsin.

Cyathaxonia Wisconsinensis, n. sp.

Among the many cyathophylloid corals of the upper Niagara formation, represented only by casts of the interior of the cup, is one having a deep elliptical cavity near the center, which has been formed by the removal of a thin, transversly elliptical and highly elevated, solid and sub-central axis, as in the genera *Cyathaxonia* and *Lophophyllum*, presenting a feature entirely new, so far as we are aware, among the corals of the middle Silurian rocks of this country. The coral must have attained a length of three inches or more, by a transverse diameter, of one and one-fourth inches, judging from the size of the casts of the cup observed. The vertical lamellæ have been strong and arranged in pairs, the secondary layers being quite subordinate to the primaries. A large deep fosset

marks the bottom of the cup on the convex side, and the upper transverse plate forming the bottom of the cup has been smooth and nearly half as wide as the coral opposite the base of the cup.

Formation and locality. In the upper part of the Niagara group, (Racine limestone) at Racine and elsewhere in Wisconsin.

Amplexus fenestratus, n. sp.

Corallum forming strong, simple, irregularly turbinate columns, often attaining a diameter of two and a half to three inches, and apparently twelve or more inches in length, with distant, strongly projecting, periodic lip-like varices, above each of which the coral is again contracted; cup deep, margin thick, except near the periodic varices, where it becomes much thinner than at other points; longitudinal rays well developed, very closely arranged, and apparently subequal; transverse plates large and strong, closely arranged, and extending to about one-half the diameter of the body. Interlamellar cystose divisions well developed and very numerous. Exterior of the coral covered, when perfect, by a thin epitheca, marked longitudinally by the rays, and transversely by small elevations at the junction of the walls of the inter-lameller cysts with the epitheca, which is generally worn through, or originally left imperfect, the spaces appearing as minute transverse or elliptical perforations in the epitheca, giving a peculiarly roughened exterior surface, which will readily be distinguished.

Formation and locality. In the lower coral beds of the Niagara group, at Cato, at Cato Falls, and at the rapids below Clark's Mills and vicinity, Wisconsin.

Amplexus annulatus, n. sp.

Corallum simple, elongate-turbinate in form, more or less curving throughout; from one and a half to three inches in length, by about five-eighths of an inch in diameter, seldom attaining more than three-fourths of an inch; the lower inch of the length much more rapidly expanding than above, where it is sometimes sub-cylindrical. Exterior surface very distinctly and strongly annulated, presenting somewhat the appearance of a species of a *Cornulites*. Longitudinal rays, numerous and moderately well developed, extending only a short distance from the walls of the polyp; transverse partitions, distinct and strong, occupying by far the larger part of the

diameter of the cup, rather distantly arranged, their distance from each other often equaling half the diameter of the tube, and more or less curved or irregular. External cup comparatively deep.

The strongly annulated external surface of the corallum is quite a distinguishing feature.

Formation and locality. In the Guelph limestone at Sheboygan and Carlton, Wisconsin; and elsewhere at the same horizon.

Stricklandinia multilirata, n. sp.

Shell of medium size but very diverse in form, varying from longer than wide to nearly one-third wider than long, and from depressed biconvex with nearly equal valves to extremely gibbous, with the ventral valve very much the deepest, as seen in profile. Hinge line straight, usually longer than the width of the shell, and often with mucronate extremities, but is frequently seen much shorter than the width of the shell below; front of the valves slightly protruding beyond the general contour, or subtruncate. Area of the ventral valve distinct but not wide. Dorsal valve with an inconspicuous or depressed umbo, and a moderately wide, poorly defined and slightly elevated mesial fold. Ventral valve more convex, with a deeper, more conspicuous and often subangular mesial depression, but a not at all prominent beak. Surface of the shell marked by numerous, distinct but not strongly marked, bifurcating, radiating plications both on the sides of the shell and on the mesial fold and sinus; the number not constant, but usually from four to six in the space of one-fourth of an inch on the margin of the shell; spoon shaped process in the interior of the ventral valve, as shown by the cavity left in the casts by the removal of the substance of the shell, distinct but not large.

Formation and locality. In the upper Niagara (Guelph), at Sheboygan, Wisconsin.

Leptodomus undulatus, n. sp.

Shell of rather more than medium size, obliquely broad-ovate in outline and highly convex; hinge-line short, not more than half as long as the shell below; beak broad and strong, but not at all prominent or projecting, situated near the anterior extremity, slightly enrolled and directed forward; umbo prominent below the beak;

anterior margin of the shell rapidly sloping backward with a convex curvature, and with the basal and posterior margin forming two-thirds of an elliptical curve; posterior margin sloping rapidly backward from the extremity of the hinge-line, and rounded below; umbonal ridge prominent and rounded; cardinal slope abrupt and slightly concave just behind the beak. Surface marked by a few strong, regularly rounded concentric undulations parallel to the margin of the shell, and regularly increasing in strength with the increased size of the shell.

Formation and locality. In the Niagara limestone (Racine), at Wauwatosa, Wisconsin.

Enomphalus macrolineatus, n. sp.

Shell large and robust, subdiscoidal with a depressed convex spire, composed of about three strong, rounded or elliptical volutions, the inner one rising but little above the next succeeding, and the last more rapidly increasing in size; transverse section of the volution apparently broad-ovate, being more sharply rounded on the outer side than above; suture lines strongly marked. Under side of the shell unknown. Surface of the volutions marked with strong, distant, angularly elevated, revolving lines or ridges, with concave interspaces on the top and sides; those on the upper side of the impression of a fragment where the volution has been a little more than one inch in diameter are about one-sixth of an inch from crest to crest. Transverse lamellose striæ are observed crossing the revolving lines and apparently rising into points on the ridges.

One fragment in the collection indicates a shell of more than four inches in diameter. The large size and strong revolving lines will readily distinguish this from any other American species.

Formation and locality. In the Niagara group (Racine), at Kuntz's quarry, Manitowoc Rapids, Wisconsin.

Raphistoma Niagarense, n. sp.

Shell of rather large size, trochiform or sub-discoidal, depressed convex above and below, and acute on the periphery; transverse diameter almost twice as great as the height of the shell, measured from the base of the aperture to the top of the spire. Volutions about three, sub-triangular in section and slightly wider than high

the upper surface very slightly convex between the suture line and the edge of the shell; lower side of the volution a little more rounded than the upper, to near the margin of the umbilicus, where it is more sharply rounded into the cavity, and vertical above. Umbilicus small and deep, exposing all of the inner volutions. Aperture sub-triangular, most acute at the outer edge, rounded on the lower inner border, and slightly modified on the upper side by the preceding volution, which is apparently overspread by the inner lip. Columellar portion thin and nearly vertical. Margin of the lip thin and sharp, strongly receding from the suture to the exterior angle of the volution, with a distinctly sigmoidal curvature, both above and below. Substance of the shell thin. Surface marked by fine striæ of growth parallel to the margin of the aparture, and also by revolving lines, which on the upper surface of the outer volution are about half a line apart, and on the under surface are finer and more numerous.

Formation and locality. In the Niagara group, eastern Wisconsin.

Holopea magnaventra, n. sp.

Shell of large size, ventricose and robust in habit; spire low or depressed — convex, volutions about three, very rapidly increasing in size and strongly rounded on the periphery; suture distinct but not deep; aperture subcircular or very broadly ovate, pointed above where it is slightly modified on the inner side by the preceding volution; umbilicus probably closed, and apparently covered by a callous on the overspreading columellar lip, as indicated by the form of the cast. Surface of the shell, as far as can be determined by the specimens, marked only by transverse lines of growth.

Formation and locality. In the uppermost beds of the Niagara group (Guelph limestone), at Carlton, Wisconsin.

Toxonema magnum, n. sp.

Shell very large and robust, spire highly elevated and rapidly ascending, the rate of increase being very gradual. Volutions in the lower part proportionally long, entire number unknown, very depressed convex on the external surface; columella prolonged below, giving an elongate-pyriform aperture; suture between the volutions, as seen on the internal casts, moderately wide, indicating a shell of considerable thickness. Surface features unknown.

Formation and locality. In the higher portions of the Niagara group (Guelph limestone) in Sec. 28, Carlton township, Wisconsin.

Pleurotomaria Racinensis, n. sp.

Shell of medium size, composed of from three to three and a half volutions, which increase very gradually in size with the increased age of the shell, and are subquadrangular in a transverse section. Spire very low, the entire height of the shell equaling only about one-half of the transverse diameter. Volutions flattened on the upper surface, and very rapidly sloping on the outer surface, the edge being nearly vertical; under surface, very depressed convex, more rapidly rounded within the broad umbilical cavity. Along the lower peripheral angle of the volution, as seen on the internal cast, there occurs a thin, sharp carina, indicating the presence of a revolving groove in the shell, and probably a slit in the margin of the lip. Surface of the cast marked on the nearly vertical exterior margin by distant, vertical ridges, at regular intervals of about one line on the outer volution of the specimen figured.

Formation and locality. In the Niagara group (Racine limestone), at Racine, Wisconsin. There is also a form undistinguishable from it, in beds, referred to the lower part of the formation, two miles south of Little Sturgeon Bay.

Pleurotomaria Laphami, n. sp.

Shell of medium size, spire conical and moderately elevated, the apical angle being about forty-five degrees, or a little less. Volutions three and a half to four, subtriangular, flattened exteriorly in the direction of the apical-angle, subangular on the periphery and rounded below; suture indistinctly marked on the exterior of the shell as shown by the impression left in the stone, but very distinct on the cast of the interior; aperture rounded triangular; umbilicus proportionally large. Surface of the shell smooth or marked only by fine striæ of growth.

Formation and locality. In the limestones of the Niagara group, at Ashford railroad cut, Ashford, Wisconsin.

Murchisonia Chamberlini, n. sp.

Shell very large and robust and of a general oval form, the example from which the description is taken being a cast made in the

natural mould left in the rock by the removal, by solution, of the shell, and measures about for inches in length by about two inches in its greatest diameter. Spire moderately elevated, the apical angle being about thirty or thirty-five degrees; volutions about six, strong and highly convex, and marked on the periphery by a strong distinct, moderately elevated, revolving band which produces a slight angularity on the upper volutions. Aperture large, broadly ovate, prolonged below, and the lip distinctly rimate. Columella strong, slightly curved below and spreading upon the body volution in the upper part, but becoming free in the lower portion, leaving a distinct umbilical cavity behind, which is open to the entire length of the spire, and in the cavity left in the rock by the decomposition and removal of the shell, had left a strong spiral core of stone, which had filled it, three-eighths of an inch thick in the lower part, remaining supported in the center by the cavity. Minute surface markings of the shell not preserved, but remains of lines of growth can be faintly traced.

Formation and Locality. In limestone of the upper portion of the Niagara group (Guelph limestone), near Carlton, Wisconsin.

Orthoceras Carltonense, n. sp.

Shell of moderate or large size, and moderately tapering, the rate of increase being about one-fourth of an inch in a length of two inches. Section circular; septa of moderate depth, and closely arranged, about eight chambers occupying a space equal to the diameter of the shell at the top of the upper one of those counted. Siphuncle unknown. Surface marked by longitudinal flutings, numbering about twenty-four in the circumference of the shell.

Formation and locality. In the upper portion of the Niagara group(Guelph limestone),at Carlton, Kewaunee county, and at Ozaukee, Wisconsin.

Cyrtoceras rectum, n. sp.

Shell of moderate size, nearly straight in form and ovate in transverse section, the lateral diameter being about three-fourths as great as the dorso-ventral, and the greatest width being on the inner side of a central line; curvature of the tube on the inner face scarcely perceptible, and the rate of increase in diameter, in the dorso-ventral direction, about an eighth of an inch, in a length of two inches; septa flat in a lateral direction, but strongly arching

along their dorso-ventral axis, so arranged that about nine chambers occupy a space equal to the dorso-ventral diameter of the outer one counted. Outer chamber not constricted at the aperture so far as observed; siphuncle proportionally large and expanded within the chambers, situated at about its own diameter from the inner or shorter curved surface of the shell. Surface features not observed.

Formation and locality. In the upper portion of the Niagara group (Guelph limestone), at Carlton, Kewaunee county, Wisconsin.

Phragmoceras Hoyi, n. sp.

Shell of medium size or smaller, very rapidly expanding, strongly curved and broadly ovate in a transverse section, rounded on the back and sharply subangular on the inner side of the curve. Outer chamber most rapidly expanding on the inner side from the base to the extremity of the lip, so that the dorso-ventral diameter at the summit is nearly once and a half greater than at the base of the outer chamber. Expansion of the aperture on the inner end, small and transverse, that of the opposite end large and ovate; connecting slit short and narrow, the contraction of the chamber approaching the slit being abrupt. Septa concave, the chambers being about three times as deep on the outer curve as on the inner side. Siphuncel small, marginal on the inner curved surface, and situated in the angularity of the transverse section. Surface marked by transverse striæ, which are strongly arched upwards on the sides of the shell a little within a central line, and very broadly curved downward on the back.

Formation and locality. In the upper part of the Niagara group (Racine limestone), at Schoemacher's quarry, near Wauwatosa, Wisconsin. A similar form but with a more compressed section and more protruding and laterally compressed lip on the inner side, occurs at Busack's quarry, which we propose to designate under the varietal name *compressum—P. Hoyi* var. *compressum.*

Phragmoceras labiatum, n. sp.

Shell rather below the medium size, rapidly expanding from below upward, and but slightly curved in its form; very regularly oval in a transverse section, lateral diameter about three-fourths as great as the dorso-ventral diameter. Outer chamber of the shell a little

wider than high, closely compressed at the top so as to entirely close the opening of the aperture along the center of the summit in some cases. Ventral opening forming a slightly expanded lip-like tube. Dorsal opening large and tubular, the tube being short and broad, and appearing as if it had been forcibly inserted into the body chamber, so as to leave a sharp, distinctly impressed suture-line at the junction. The lower side of the tube forms a section of an oval figure, while the upper half is deeply impressed on each side of the central slit or opening, giving a deeply trilobed form to this part of the tube. Septa moderately concave, arranged so that about six chambers occupy a space equal to the lateral diameter of the outer one counted. Siphuncle rather small and submarginal. Surface of the shell unknown.

The form of the apertural tubes is a distinguishing feature.

Formation and locality. In limestones of the Niagara group at Ashford, Fond du Lac county, Wisconsin.

Illœnus pterocephalus, n. sp.

Cephalic shield short, broad, and of unusual depth, when viewed in its natural position with the occipital border forming a vertical line; the distance from the under surface of the head to the highest part of the glabella being, nearly or quite, twice that from the occipital line to the anterior margin. The extreme width of the head including the movable cheeks is equal to three and a half times the length. Movable cheeks small, forming thin wing-like expansions at the sides of the head and on a line with the occipital border, but so contracted anteriorly as to be scarcely more than half as long as the glabella; anterior margin and surface of the head rounded and highly convex in the middle, rapidly contracting in front of the eyes and expanding laterally along the occipital border. Glabella and fixed cheeks united but without the movable cheeks, elliptical or oval in form, very convex on the surface and nearly half as wide again as long, broadly rounded in front and strongly lobed in the posterior part by the dorsal furrows, which are short and directed inward, but are not visible on the cast beyond the posterior third of the head, as measured along the curve of the glabella. Eyes prominent and obtusely pointed as shown in the cast, and situated very near the posterior margin of the head. Facial suture cutting the anterior margin considerably

within the line of the eyes and passing to the eye with a regular outward curvature; behind the eye it passes almost directly to the posterior margin. Thorax and pygidium unknown.

Formation and locality. In the Niagara limestone at Pewaukee, Wisconsin.

Bronteus Laphami, n. sp.

Entire form unknown, the specimens from which the following description is taken, consisting of fragments of the glabella and several imperfect pygidi.a

Glabella short and broad, very depressed convex, the division of parts somewhat obscure. Anterior lobe very broad in front, and rapidly decreasing in width from its junction with the marginal rim to behind the middle of its length, where it is not more than two thirds as wide as in front; dorsal furrow obscure; posterior glabellar furrow well marked; occipital furrow distinct, and the occipital ring rather large. Fixed cheeks narrow, rather strongly lobed; anterior marginal rim of the head narrow and rounded, indistinctly separated from the anterior lobe of the glabella in the middle, but not definitely so at the sides, its surface rather strongly striated.

Pygidium paraboloid in form, and depressed convex, with an entire external margin; anterior border of the shield gently rounded and moderately convex on the surface, lobation distinct. Axial lobe short, rounded-obconical in form, more strongly convex than the lateral lobes, and marked by a single narrow articulating ring on the anterior end; lateral lobes gently convex on the inner part, more abruptly declining at about the outer third of their width, and slightly recurving again near the border; articulations very distinct, and directed strongly backward in their course to the margin, rounded on the surface and separated by short, deep depressions to near the border of the shield, just within which they become obsolete. The central rib, or that extending from the termination of the axial lobe, rapidly narrows for one-third of the length from the anterior margin of the shield, then more abruptly widens to the posterior margin, where there are very slight indentations in the external border corresponding to the depression at its sides. Near the middle of the length of this central articulation, or rib, there rises a central depression, or furrow, dividing it from this point

posteriorly into two divisions, presenting the appearance of a bifurcation.

Surface of the crust of the pygidium marked, on the lower part of the lateral expansion, by strong squamose concentric lines. Other portions of the plate smooth.

Formation and locality. In the Niagara group (Racine limestone), at Kewaunee, Wisconsin. Named in honor of the late Dr. I. A. Lapham.

APPENDIX.

IN MEMORIAM. — MOSES STRONG.

June 17, 1846.——Aug. 18, 1877.

The lapse of a geologic age is little to us save in the record it has left us. The infinitude of its days are of little moment if they form a "Lost Interval." The *record* is little to us save in its character. An eon of ages may have heaped up an immensity of sands, but if they have buried neither life nor treasure, it is but a Barren Interval. The years that formed the coal, the ore and the life beds, however brief among the eras of the earth's history, are more to us than all lost or barren intervals, however vast their cycles. So the eon of life. June 17, 1846 —— Aug. 18, 1877. These are the limiting signs of human age. What is the record?

The earlier years of Mr. Strong's life, the period of fundamental intellectual deposit and moral accretion, were spent where the basal strata of character are best laid, at home.

His early training and instruction were largely received at hands of an intellectual father and a pious mother, the combination which best matures thought and develops morals. To this was added something of the cosmopolitan culture of the public schools. In his thirteenth year he entered the French and English school then located at Sauk City, where he acquired some knowledge of the rudiments of the versatile language of the French. A collegiate course had, however, been selected as an important feature of his education, and in his fourteenth year his studies were turned specifically in that direction under the tuition of the Rev. Mr. Skinner, then rector of the Episcopal Church at Mineral Point. The last few months of these preparatory studies were passed at Delavan in this state, whither Mr. Skinner had removed, and

some of the citizens of that place will recall the quiet, manner of the young student. Let it be noted that thus far, more than half the span of his life, he had been chiefly under the quiet but potent moulding power of parental and pastoral influence. Under these auspices the predominant traits of his character were formed and the most important part of his education accomplished, the education that looks toward manhood.

But, though the home is wide enough for the boy, the world is none too broad for the man, and Mr. Strong now entered upon that wider culture which was to fit him for the still broader school of life. In September, 1863 he was admitted to Yale College, in whose classic atmosphere he passed the succeeding four years. It was in our judgment a fortunate circumstance, in view of the fact that he subsequently turned his attention so largely to engineering and scientific studies, that so considerable an element of literary study entered into his course at this period. In the junior year of his college course, he selected the profession of mining engineer as his life pursuit, and during the remainder of his course his reading outside of his class studies, was mainly such as was germane to his chosen profession. Immediately after his graduation he was afforded an opportunity to engage in practical civil engineering in connection with the survey of a railroad line along the Mississippi, between La Crosse and Winona. This work, however, was cut short by sickness.

In the fall of the same year he returned to New Haven, and spent the year in the Sheffield Scientific School, in the study of natural science, higher mathematics, drawing, and kindred studies. In the pursuance of these studies he was much indebted to Prof. Brush of the chair of mineralogy and metallurgy, who had completed his education in Germany, and by whom Mr. Strong's desire to complete his own education in that country was stimulated to its consummotion.

Mr. Strong sailed for Germany in July, 1868, and returned in the same month of the year 1870. His first year was spent in the mining school at Clausthal, in the Hartz mountains; and the second at the celebrated school at Freyberg, in Saxony. These two years afforded excellent facilities for the pursuit of his professional studies, both in the extensive mines and the ample laboratories.

Soon after his return from Germany, Mr. Strong engaged in the

practice of his profession, the survey of the extensive lead mines of Crawford, Mills & Co., at Hazel Green, being his first engagement. Upon the completion of this, he was entrusted by the firm with a financial mission to New York.

It was always the intention of Mr. Strong to pursue the work which he had planned for his life in the mines of the west, but his devotion to his parents, and his attachment to the home of his infancy and youth, and its domestic associations, were so great that he was reluctant to remove to so distant a field of labor, so long as he could be profitably engaged without permanently disturbing the ties and affections which bound him with such devotion to the scenes that had given so much pleasure to his earlier years.

Deeming a practical acquaintance with civil engineering, especially so far as relates to the location and construction of railroads, a valuable accessory to his profession, as mining engineer, he became associated for varying periods, and in different capacities, in the location of the Northern Pacific, the Wisconsin Central, and several preliminary lines in the lead region.

On the inauguration of the geological survey in 1873, Gov. Washburn, upon the recommendation of the late Dr. I. A. Lapham, then chief geologist, commissioned Mr. Strong as assistant state geologist. During the years 1873 and 1874, he was engaged chiefly in the examination of the lead region. In 1875 he extended his work, adjacent to the Mississippi, as far north as Trempealeau county.

The year 1876 was chiefly devoted to the Copper-bearing series in the northwestern part of the state.

The history of Mr. Strong's work during the past year, and of its calamitous close has already been given on a previous page. He fell in the midst of his work, in its active prosecution. His last notes were recorded but a few moments before they were submerged with him beneath the fatal rapids. The life passed away, but its latest record remained. These last recordings are marked by blanks. The formation had been described, but spaces were left for the location, which was not then determined. These blanks may be filled, but he has left other blanks we may not fill. He fell *pushing up the stream* — in fact and in symbol — not floating down it. *He stood at the prow*, pressing onward and upward, with duty for his motive and truth for his aim.

Of his investigations in connection with the survey, I need not speak. "Let his works praise him."

In character, he was modest and unassuming, and commanded respect rather by the merits he could not conceal than by any that were assumed. His quiet manner never revealed the real executive strength which he possessed. He accomplished more than he seemed to be attempting. His quiet self-possession gave steady and effective direction to his activities, and stood as a bar alike to the aberrations of mental confusion, the effervescence of merely emotional enthusiasm, and the turbulence of illusive energy. Judiciousness in the application, rather than the absolute amount of energy displayed, characterized his efforts.

His retiring disposition excluded aggressive personal ambition, and his self-assertion was limited to that called forth in the discharge of his duties. His personal advancement was due to inherent merit or the efforts of others, rather than to self-zeal and assurance on his part.

Candor and sincerity were eminent traits of his character, and honesty of expression marked alike his life and his language. His integrity was absolutely above question. No bond but his honor was requisite for the security of whatever trust was reposed in him. In attestation of his attractive personal traits, he enjoyed the warm friendship of his associates, and, in an unusual degree, the esteem of the community in which he was so well known.

In harmony with his whole nature, Mr. Strong's religious convictions were of the practical rather than the emotional type. Conscientiousness in the fulfillment of every relationship of life was the fundamental stratum upon which was erected the temple of his faith. In outward recognition of his persuasions, he became a member and regular communicant of the Protestant Episcopal Church.

If he could have chosen the form of his departure, and could have so moulded it to best portray at once the soul of his ethical and religious views, he could perhaps have chosen nothing more fitting than that which the hand of destiny selected for him, to die from the perils that encompass duty, to die for his friend.

His domestic relations were most felicitous. Love given and received made his dwelling place a genial home. A kind father, a happy wife, and two lovely children, formed the hearth circle. The household Penates always seemed to smile. That they are now broken and veiled, is the saddest thought of this sad story.

Beloit, January 6, 1878.

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